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M. N. FORNEY, ... Editor and Proprietor.
FREDERICK HOBART . . . . . Associate Editor.

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MR. FREDERIC ALGAR, Nos. 11 and 12 Clements Lane, Lombard Street, London, E. C., England, is the authorized European Agent for the JOURNAL.

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THE relations of the railroads to the timber production and supply of the United States are the subject of a report issued by the Department of Agriculture, which deserves attention. The question is not a new one, but it is necessarily of great interest, and its importance must increase every year as the demand for lumber increases and the sources of supply are diminished. While the area of untouched timber lands is still great, it must be remembered that the consumption is continually growing, and that the railroads are every year opening up new districts to be stripped by the lumbermen. The care of timber lands and the growth of new timber are questions which will probably become of pressing importance in this country much sooner than is generally anticipated. Forestry as a science is almost unknown here, and anyone who desires to study it must go to Europe for masters and for the results of experience.

The efforts of the Department of Agriculture to awaken interest and to disseminate information on this question are deserving of praise, and it is to be hoped that they will be continued.

THE report on the use of iron and steel ties in Europe, a summary of which is given on another page, is an interesting summary of what has been so far done in the substitution of metal for wood in railroad tracks in the leading European countries. The use of metal ties has made much more progress there than in this country, chiefly because of the comparative scarcity and higher price of lumber.

That ties of iron, and especially of steel, will do good service is generally admitted, and the discussions over their use, from a technical point of view, are limited chiefly to argument as to the best form to be adopted. Economically, however, the question of the use of wood or metal for this purpose is an open one and must be decided specially in each case. In several European countries—especially in Belgium, Holland and Germany—the decision seems to be in favor of the metal tie, which is now gradually supplanting wood both in new construction and in renewals. In England and France the question is an open one yet, and comparatively little has been done, while in Sweden, Russia and Austro-Hungary—all countries with extensive forest resources—hardly anything has been done, and the use of wood is, and will probably remain, universal.

THE peculiar geographical situation of Denmark has forced its railroad engineers to plan several distinct systems of railroad, which could only be connected with each other by crossing arms of the sea whose width and depth forbid all attempts to bridge them. The communication of Copenhagen with the mainland and the general railroad system of Europe is broken up very much as that of New York would be, for instance, if all its business with the interior had to take the Long Island Railroad to Greenport and then cross Long Island Sound to Stonington or New London. How the Danish engineers and their marine advisers have met the problem is told in an interesting article on another page.

While they do not seem to have come to America for advice, it is interesting to note that in many respects they have come pretty near to American practice, while there may be some points in which the difference is worth studying.

The Danish railroad system is not very large, nor is its traffic very heavy, but, in the steam ferries used, it has been provided for in such a way that a much greater business could be handled with little or no increase of the permanent plant on shore. More ferry-boats would really be all the addition needed were the traffic to be doubled.

THE NAVY has, so far, had the larger appropriations and has done more toward adopting modern appliances than the Army. The Ordnance Department of the land service has not been idle, however, and is actively employed in fitting up its heavy-gun factory at the Watervliet Arsenal with the best appliances which its present limited means will permit. At present, only the smaller guns can be made there, but it is to be hoped that heavier tools will be supplied as needed, and a plant equal to making the largest guns required will be brought together.

The Government will not, it is understood, attempt to make its own steel, but will continue to call on the steelmakers of the country for the castings and forgings which are to be finished in its own shops.

FURTHER experiments with the Zalinski dynamite gun tend to show that its range can be considerably increased over that shown in previous public trials. Whether the weight and initial velocity of the projectile will be sufficient to give it accuracy at longer ranges seems hardly to be fully proved as yet, although, in the experiments here referred to, the shots fell close to the mark at a longer range than had been before attempted. The later trials were directed entirely to this point, the shells being loaded with sand instead of dynamite, so that there was no showing made as to the effect of their explosion.

The main objection now made by the opponents of this weapon is that the great length of the gun makes it awkward and unwieldy to handle, especially on shipboard. This does not seem to be an objection of sufficient weight

to stand very seriously in the way of its adoption for the purposes for which it will chiefly be used in warfare. It is not claimed that the gun will supersede those now in use, or that it will do away with the use of gunpowder, either for propelling shells or exploding them in military or naval operations. It has, apparently, established its place as a useful auxiliary to coast batteries and ships' guns and a formidable weapon for attack or defense. There is little doubt that it will play an important part in arming our future coast fortifications.

A PRACTICAL trial of a night torpedo-attack was recently given at Newport, R. I., where the new cruiser *Atlanta* was made the point of attack for the other vessels of the Navy there assembled. Torpedoes were not brought into actual use, of course, as the Navy could hardly afford to blow up the latest addition to its numbers, but the methods to be employed in carrying out and resisting an attempt to disable or destroy a hostile vessel were well and practically illustrated. In this case, the *Atlanta* came out the best, its officers and crew being able to detect every approach of the enemy and to take the necessary steps to meet it with the appliances with which the ship is furnished. The only thing lacking to the completeness of the trial was the presence of one or two completely equipped torpedo-boats of the modern pattern.

The most prominent feature in this sham battle was, perhaps, the usefulness of the electric search-lights which were, on this occasion, fully tried for the first time in this country. These lights, it would seem, are fully shown to be really indispensable to the modern warship, if it is not to be at the mercy of apparently insignificant antagonists. Their use is only another proof of what a complicated machine such a ship has grown to be. The old fighting naval officer is now a comparatively insignificant person on board a ship which must be managed largely by engineers, and on which an expert electrician is almost as important as a skilful gunner or an experienced navigator.

THE change of control of the Baltimore & Ohio Railroad, which has been effected in the past month, is really one of the most notable railroad events of the year. The Baltimore ownership, represented and dominated by the late John W. Garrett, and by his son and successor in lesser measure, has so long controlled the company that the possibility of a change has hardly been considered, and when it was announced early in the year that negotiations were in progress for the sale of a majority of the stock, the statement was received with incredulity, especially when the parties to whom it was to be made were mentioned.

The first negotiations fell through, as had been generally anticipated, but at the right moment the transaction was taken up and completed by a syndicate of bankers, whose composition leads to a general belief that the line will be practically managed in the interest of the Pennsylvania Railroad. This belief is certainly well founded, at least to the extent that the Baltimore & Ohio, while nominally remaining an independent line, will never again be found in active conflict with the Pennsylvania. How much this means those who are familiar with railroad history for the past 20 years will appreciate.

While it is not intended to say anything here of the general policy and methods of the elder Garrett, it may be said that, in an engineering sense, there may, and very likely will, be a distinct gain to the road in a change of management. The Baltimore & Ohio was originally the work of some of the greatest engineers which this country has produced, but in later years it has been distinguished by an obstinate conservatism, which continually opposed all new methods and was not willing to concede that any change could be for the better. This was supplemented by a system which left no room for individuality in subordinate officers, and made every department of the road absolutely subject to the will of the chief executive in the smallest details.

Under such a system men of ability do not often take positions and do not hold them long. While the old management of the company has done some excellent things, it failed entirely in others, and the road has not been well managed from an engineering point of view for many years past. It is to be hoped that new men will mean new methods in this case, and a general improvement.

ONE result of the change of control of the Baltimore & Ohio Railroad has been the transfer of the telegraph system built up at great expense by its managers to the Western Union Company. This removes the only considerable opposition which the Western Union has had, and leaves that company practically alone in the field.

This is to be regretted for many reasons, and will probably give a great impulse to the movement for a Government telegraph system as the only practicable, if not the best, means of escape from the present monopoly.

It is true that a single company can work the telegraph lines of the country more economically than several companies more or less in competition, and its advocates therefore claim that it can afford to do the business much better with more satisfaction to the public.

It is also true, however, that the public is not at all satisfied to see so indispensable an agency as the telegraph entirely in the hands of one corporation—especially when that corporation is controlled by a man who is generally and profoundly distrusted.

THE accident at Kouts station on the Chicago & Atlantic road on October 11, was, apparently, due to the absence or failure of signals to warn any train which might be approaching from the rear a passenger train which had been stopped in an unusual place by a slight breakage of the engine. It is stated that there was a distant signal some 1,500 ft. away from the water-tank where the collision took place, and that a brakeman on the disabled train pulled the lever by which this signal was operated. Whether the connection was broken or the semaphore out of order, or whether the engineer of the second train failed to see the signal, does not clearly appear from the published accounts of the collision; no other attempt was made to give warning, and the collision occurred in a very short time after the first train stopped.

The consequences, apparently, would not have been very serious, had not the wreck caught fire from the car stoves. In it nine persons were killed, all of whom would probably have been saved, had it not been for the fire. The wreck would have resulted only in slight injuries to nine or ten persons had it not been for the stoves, and would have passed almost without general notice.

In this case, therefore, the loss of life was due directly

to the stoves in the wrecked cars. The breaking up of the cars, however, which upset the stoves and liberated the fires which they held, was due to their imperfect construction, and might have been prevented by methods of building, to which reference has heretofore been made in our columns. In fact, the sleeping-car, which was at the rear end of the train and so received the full force of the collision, was but little damaged by the shock. It was driven forward by the engine which struck it, and crushed the lighter cars in front.

The accident, therefore, is only one more added to the many which have preceded it, which are to be taken as arguments in favor of a method of building cars which will prevent telescoping—the greatest danger in an accident of this kind with the usual pattern of passenger car.

THE accident on the Chicago & Atlantic, with the fatal results following the burning of the wreck, comes early in the season and has given a fresh impetus to the discussion of the car-heating question. The immediate result is an increased popular demand for the abolition of all stoves in the cars, which necessarily involves the introduction of continuous heating, either by steam direct from the locomotive or from a special car provided for the heating apparatus. The inventors of heating apparatus of this kind are, of course, taking advantage of their opportunity, and are presenting the claims of their respective devices energetically and with considerable success.

The present winter will see many advances made in this direction, and quite a number of the different methods of continuous heating will receive extended trials on different roads in active service. The success of these trials will largely determine to what extent the use of steam from the locomotive for heating will be introduced. A severe winter will bring out the weak as well as the strong points of the different systems, and will give a fair opportunity to remedy defects.

It is not at all probable that any one of the continuous steam-heating systems now on trial will be generally introduced to the exclusion of others. All of them have merits, and there are probably several which will come into extensive use. In this connection the action which the Western Railroad Club has taken in starting a movement to secure, if possible, uniformity in couplings for steam pipes on cars is worthy of commendation. Certainly such uniformity is desirable, and it will be easier to secure now than later.

THE New England Roadmasters' Association had a brisk and well-attended meeting at Hartford last month. There are, indeed, many things to be said in favor of distinct associations of this kind, where the members can all understand and appreciate local needs, and where they can be gathered together with comparatively small expenditure of time on travel.

On the other side, however, is the fact that district associations are apt to become too local and provincial and to lack breadth of view and something of that knowledge which, in larger associations, is the result of the friction of opposing ideas.

Perhaps a combination of the two—district and national—would be the best plan for the Roadmasters, as well as for some other associations.

THE fastest tracklaying on record, it is claimed, has been done this past summer on the Montana extension of the St. Paul, Minneapolis & Manitoba Railroad. The total length of this extension is 550 miles, and the track was all laid between April 2 and October 16; a total of 196 days, which gives an average, allowing for bad weather, of fully three miles a day. The heaviest day's work actually done was 8¼ miles; the heaviest week showed an advance of 32½ miles, and the heaviest month—August—115 miles.

The only time when this record has been approached was on the Canadian Pacific, on some of the Western sections.

A LONG and elaborate paper on aluminum bronze as a substitute for steel in the manufacture of heavy guns was read by Mr. Alfred H. Cowles at the October meeting of the Naval Institute. Mr. Cowles is an expert in the use of aluminum and can doubtless present its claims in the best possible light. His paper, however, is presented to an audience skilled in the manufacture and use of heavy guns and will meet with severe criticism. The advocates of steel will not yield their ground to a comparatively untried metal without a struggle.

This is a case, however, in which argument can finally settle nothing, and actual trial will be necessary to decide.

AUTOMATIC CAR-COUPLERS.

THE announcement has been made of the results of the letter-ballot of the Master Car-Builders' Association on the adoption, or rather recommendation, of the Janney—or, as it has since been named, the Master Car-Builders' type of car-coupler. It may be well to explain that it is provided in the constitution of the Association named, that any proposition recommending the adoption of standards of construction must be submitted for discussion at one of the meetings, after which a vote is taken to decide whether the proposition shall be submitted for decision by letter-ballot to all the members. If decided in the affirmative, the Secretary is required to mail to each member a blank ballot and a copy of the proposed recommendation. The ballots must then be filled up, and signed by the members, and remailed to the Secretary, who is authorized to count the ballots, within 60 days from the date they were sent to members. On matters submitted in this way, active members of the Association each have one vote, and representative members—that is, members appointed by a President, General Manager or General Superintendent of a railroad to represent it in the Association—each have one vote, and in addition thereto, one more vote for each full one-thousand cars which are owned by the company he represents.

It may be well to explain still further, that, after discussing the question of automatic couplers for a number of years, the Association referred the subject to its Executive Committee. At the last annual convention held in Minneapolis that Committee made a report with the following recommendation:

> Your Committee feels that the status of the problem at the present time, as here stated, warrants them in making the recommendation that this Association recommend, as a standard form of coupling, the Janney type of coupler; that the Association procure one of the present make of Janney coupler, selection being made by a committee appointed for that purpose, and then all other forms of couplers that will automati-

cally couple to and with this coupler, under all conditions of service, are to be considered as within the Janney type and conforming to the standard of this Association.

After the report of the Committee was read and discussed a resolution "that the recommendation of the Executive Committee be adopted and acted upon" was passed. In accordance with this action the Secretary sent out a circular in which it was said that "at the last convention of the Master Car-Builders' Association it was agreed to submit the following recommendation for decision by letter-ballot.

"That the Janney type of coupler be recommended as a standard of coupling."

A postal card to be used as a ballot, was inclosed with the circular—which contained the question—"are you in favor of the adoption of the Janney type of coupler as the standard of the Association?"—and members were requested to write "yes" or "no" after the question.

In response thereto 109 members out of a total of 242 cast their ballots. Of these 8 were rejected because the members had not paid their dues, as required by the constitution, and one was received too late to be counted. In all there were 668 valid votes cast, 474 in favor of recommending the Janney type of coupler as a standard and 194 opposed to such recommendation. Two-thirds of all the votes cast are required for the adoption of such a measure. It was therefore declared adopted at a meeting of the Executive Committee held on October 13.

In order to carry out the recommendations of the Executive Committee, made in their report on couplers, a sub-committee was appointed at the meeting referred to "to critically examine the different forms of couplers coming within the Master Car-Builders' Type, and report the result of their examination to the Executive Committee."

This brief statement of the action of the Master Car-Builders' Association is given, because it does not seem to be very distinctly understood just what the action has been. It may be added that the Executive Committee decided that what has been known as the "Janney" type of coupler shall hereafter be called the "Master Car-Builders'" type. Those who do not know anything about the kind of coupler referred to can form an idea of what it is if they will hold the right hand with its palm vertical and bend the fingers to approximate to a half-circle, or, perhaps more accurately, a half-hexagon, and extend the thumb. Then reverse the other hand, so that the two palms will face each other, and bend the fingers so that the fingers of the two hands hook into or engage with each other. The part of the coupler which is represented by the fingers of each hand is described in Janney's patent as a "rotary crank," or, more accurately, a rectangular lever pivoted at its angle. By turning on their pivots, two couplers are made to engage and disengage with and from each other. An automatic "catch-lever," or spring-latch is added to lock the arm of the rotary hook when two draw-heads are coupled together. A "guard-arm"—represented by the thumb in the illustration with the hands—is provided, to prevent the hooks from separating laterally from each other and thus becoming disengaged when the cars are coupled together.

In his patent Mr. Janney says: "The essential features of my invention are the rotary hook, guard-arm, which serves also as a guiding-arm, and the catch-lever for holding the arm of the hook."

To get a correct idea of the present status of this subject, it should be known that the constitution of the Master Car-Builders's Association provides that "the action of the Association shall have only a recommendatory character, and shall not be binding upon any of its members or the companies represented in it." The action of the Association, therefore, has been simply to recommend railroad companies to adopt the Master Car-Builders' type of coupler as a standard.

Undoubtedly this will have a great influence on the action of the State Legislatures, railroad commissioners, and the railroad companies of the country. It is doubtful whether any considerable movement would have been made by railroad companies, looking to the adoption of automatic couplers, had it not been for the pressure brought to bear upon them by the Legislatures of different States. In most cases a certain measure of discretion has been left to the railroad commissioners in determining which couplers may and which may not be used. Inasmuch as a very small proportion of the persons who are railroad commissioners have any considerable knowledge of the mechanics of railroads, probably very few of them would feel disposed to assume a position contradictory of or opposed to the conclusion which has been reached by the Master Car-Builders' Association. The need of protection against legal penalties, in case of injury to employés, will make most, if not all railroad companies very loth to adopt any type of coupler which the Association has tacitly condemned by *not* recommending it. For these reasons it seems probable that not many more automatic couplers which are not of the type which has been recommended will be put into service.

The Association has undoubtedly acted wisely in recommending a "type" of coupler and not any one special form. Through the sub-committee which has been appointed it will undoubtedly select some one form of coupler, with which all that belong to the type recommended must couple. This will lead to a process of the survival of the fittest. Yet the importance of adopting some definite forms and proportions for a standard coupler is very apparent. The more or less conflicting and rival inventions and patents are now obstacles to this action, but probably some eliminating or consolidating process will soon remove the difficulties which now stand in the way of adopting such a standard as the interchange of traffic will demand. No matter what special form of coupler is adopted, it is of the utmost importance that it should be well designed and constructed. It is very remarkable how little importance is ordinarily assigned by railroad officers, who are are not mechanics and engineers, to the design of the mechanism to be used on railroads. It is, of course, true that what in patents is called the principle of an invention is of fundamental importance; but an invention with a good principle is often a failure and useless because the practical details and construction have not been properly worked out. The difference in mechanism when well designed is exactly analagous and comparable to the difference between a picture painted by a good artist and the work of a "duffer." You may give each the same subject, or "scheme," or "principle," and the same canvas and colors, and the artist will make a picture which will be a thing of beauty and command a high price, whereas if the paints are manipulated by an incompetent painter, his work will be worth little or nothing. Now, there is an analogous, if not the same, difference

between the work of a good designer of mechanism, and that of a person who has not the kind of ability which comes from natural aptitude, experience and skill in doing such work. The Master Car-Builders have recommended a principle; the important work of reducing that principle to practice still remains to be done.

THE ELEVATED RAILROADS IN NEW YORK.

GREAT complaint is made of the insufficient accommodation now provided for passengers on the New York elevated railroads. The cars are most insufferably and outrageously overcrowded. Passengers complain, the newspapers scold, and the railroad company complacently collects the public's nickels, knowing that the more uncomfortable the people are the greater will be the dividends on their watered stock. The "public-be-damned" policy is the one which apparently has been adopted, and "let the people stand" is Mr. Sage's dictum from which he may think there is no appeal. It has been repeated so often that the company is running all the trains it can, that generally the statement is not questioned. The fact, though, that there are a great many more trains on Third Avenue than there are on Sixth, shows that on the latter line at least it is possible to increase the train service. At any rate, it is important to know in some conclusive way whether the company can or can not afford better accommodation. If it can, it should be compelled to do so—if it cannot, it is a good reason for granting authority for the construction of other roads.

Under the laws of the State of New York it is made the duty of the Board of Railroad Commissioners to investigate just such cases and suggest remedies. The law creating the Board provides that the Commissioners "shall have the general supervision of all railroads and railways, and shall examine the same and keep themselves informed as to their condition and the manner in which they are operated, *with reference to the security and accommodation of the public.*"

The law provides further that:

Whenever, in the judgment of the said Board of Railroad Commissioners, after a careful personal examination of the same, it shall appear * * * * that any addition to the rolling stock * * * * or that any change in the mode of operating the road and conducting its business is reasonable and expedient in order to provide for the security, convenience *and accommodation* of the public, the said Board shall give notice and information, in writing, to the corporation, of the improvements and changes which they deem to be proper, and shall give such corporation an opportunity for a full hearing thereon; and if the corporation neglects to make such repairs, improvements and changes, within a reasonable time after such information and hearing, and shall not satisfy said Board that no action is required to be taken by it, the said Board shall present the facts in the case to the Attorney General for his consideration and action; and shall also report the same facts in a special report or in the annual report of said Board to the Legislature.

The present condition of things on the Elevated Railroads is certainly such as the law contemplates should be investigated by the Commissioners. If after investigation they find that the Company could, but does not, furnish the accommodations needed by the public, a report to that effect would undoubtedly have some weight with the Company, and influence on the Legislature during its coming session. If they find that the Company cannot supply additional facilities it would be proper for the Commissioners to recommend such legislation as may be required for the construction of additional lines of road, as was recently suggested by a Board of Rapid Transit Commissioners.

It is, happily, the privilege of any citizens to petition the Board of Railroad Commissioners to make the suggested investigation, and it is undoubtedly their duty to do it after, if not before, their attention is called to the evil. Anyone disposed to call the attention of the Commissioners to the outrageous and insufferable lack of proper accommodation on the elevated railroads can do so by cutting out or copying the following petition, pasting it on a sheet of paper, signing it and addressing it to the Board of Railroad Commissioners, Albany, New York. By inducing others to sign, its weight will, of course, be increased:

NEW YORK..........1887.

To the Board of Railroad Commissioners of the State of New York:

The inadequate accommodation for the transportation of passengers on the Elevated Railroads in this city is now notorious. As the laws of the State of New York make it the duty of your Board to investigate such cases, and suggest improvements and changes required for the reasonable accommodation of the public, you are hereby requested to examine into the manner of conducting the traffic on the roads referred to, and take such further action as you may deem proper to remedy the evil complained of. Respectfully (Signatures).

This would be a direct and practical method, and if such petitions were presented, the Railroad Commissioners would undoubtedly take action on them.

BOOKS RECEIVED,

THE ENGINEERING AND BUILDING RECORD. New York. This is the new title adopted by the journal heretofore known as the *Sanitary Engineer*, the old name being retained as a sub-title. While a change in name of an established paper should always be avoided, if possible, there are in the present case some strong reasons for it. The new name expresses much better the real character and scope of the paper, while the old one was to some extent misleading, as indicating a more contracted field than that really occupied. The *Engineering and Building Record* is a paper whose excellence and independence merit continued prosperity, and should secure for it a wide circle of readers.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS: VOLUME VIII, 1887. New York; published by the Society at the office of the Secretary, No. 280 Broadway.

ANALES DE INGENIERIA: ORGANO DE LA SOCIEDAD COLOMBIANA; published by the Society, Manuel Antonio Rueda, Director; Diodoro Sanchez, Secretary.

NYSTROM'S POCKET-BOOK OF MECHANICS AND ENGINEERING: REVISED AND CORRECTED BY PROFESSOR WILLIAM DENNIS MARKS, PH. B., C. E. Philadelphia; J. B. Lippincott Company (Price, $3.50). This is the nineteenth edition of Nystrom's well-known work, and has been carefully revised and brought up to date, with much original matter. The chief additions in this edition are an elementary article on dynamic electricity and one on the expansion of steam.

THE RELATIVE PROPORTIONS OF THE STEAM ENGINE: BY PROFESSOR WILLIAM DENNIS MARKS, PH. B., C. E.

Philadelphia; J. B. Lippincott Company (Price, $3.00). This is the third edition of Professor Marks' well-known book, and is revised and enlarged, the new matter to the present edition being a chapter on limitations of the expansion of steam, and some new tables. For the use of students the book is interleaved with blank pages on which notes, additions, etc., can be written.

ELEMENTARY TREATISE ON ANALYTICAL MECHANICS: BY PROFESSOR WILLIAM G. PECK, PH. D., LL. D. New York and Chicago; A. S. Barnes & Company (Price, $1.65). This is an addition to Professor Peck's series of mathematical works. It was originally written with a special view to use as a text book in the Columbia College School of Mines, but it will be found a valuable book to many who have passed the school of science but need a book of reference.

A MANUAL OF THE PRINCIPLES AND PRACTICE OF ROAD-MAKING: BY W. M. GILLESPIE, LL. D., C. E.; EDITED BY CADY STALEY, C. E. New York and Chicago; A. S. Barnes & Company (Price, $2.50). This is the tenth edition of Gillespie's standard work.

ELEMENTS OF SURVEYING AND LEVELING: BY CHARLES DAVIES, LL. D.; REVISED BY PROFESSOR J. H. VAN AMRINGE, PH. D. New York and Chicago; A. S. Barnes & Company (Price, $2.00). Davies' Surveying is too well-known as a standard elementary work to require extended mention.

THE HOTCHKISS REVOLVING CANNON: BY LIEUTENANT EDWARD W. VERY, U. S. N. Paris, France; printed for private circulation.

THE HOTCHKISS SYSTEM OF RAPID-FIRING GUNS: DESCRIPTIONS AND ILLUSTRATIONS. London and Paris; printed for private circulation by the Hotchkiss Ordnance Company, Limited.

HANDBOOK OF THE HOTCHKISS TWO-POUNDER MOUNTAIN GUN. Paris, France; issued by the Hotchkiss Ordnance Company, Limited.

OCCASIONAL PAPERS, INSTITUTION OF CIVIL ENGINEERS. London, England; issued by the Institution. The present issue includes several papers of value. The titles are: Leaks in Water Mains, by Messrs. Bryan, Fraser, Restler and Francis; River Tees Improvements, by John Fowler; Flour Mills and their Machinery, by Alfred Chatterton; South African Rivers, by W. B. Tripp; Sinking Pits at Gneisenau, by H. Tomson; Ceylon Government Railways, by F. J. Waring; Removal of Sand at the Liverpool Landing Stage, by W. H. le Mesurier; Experiments on the Strength of Iron and Steel, by John Platt and Robert F. Hayward; Use of Cast-Steel in Locomotive Engines, by Alfred J. Hill; Lumber Industry of Ontario, by M. J. Butler; Abstracts of Papers from Foreign Transactions and Periodicals.

REPORT ON THE RELATION OF RAILROADS TO FOREST SUPPLIES AND FORESTRY: COMPILED BY B. E. FERNOW, CHIEF OF THE FORESTRY DIVISION, DEPARTMENT OF AGRICULTURE. Washington; Government Printing Office.

THE SUTRO TUNNEL COMPANY AND THE SUTRO TUNNEL: BY THEODORE SUTRO. New York; published by the author.

PROCEEDINGS OF THE TWENTIETH ANNUAL CONVENTION OF THE AMERICAN INSTITUTE OF ARCHITECTS, HELD IN NEW YORK, DECEMBER 1-2, 1886: A. J. BLOOR, EDITOR. New York; issued by the Institute.

DISCHARGE OF WATER OVER WEIRS: BY CHARLES SLAGG. London, England; issued by the Institution of Civil Engineers.

THE YANEGASE-YAMA TUNNEL: BY KINSKE HASEGAWA. London, England; issued by the Institution of Civil Engineers.

NOTES ON RAILROAD CONSTRUCTION IN THE RIVER PLATE, ARGENTINE REPUBLIC: BY THOMAS HOLMES PERRY. London, England; issued by the Institution of Civil Engineers.

OBITUARY.

EX-GOVERNOR ALEXANDER H. HOLLEY, who died at his residence in Lakeville, Conn., October 2, aged 83 years, was for many years largely interested in iron-making in Western Connecticut and Massachusetts. His father, John Milton Holley, was of the firm of Holley & Coffing, who, at Salisbury, cast the first iron cannon made in this country. Mr. Holley accumulated a large fortune and was elected Lieutenant-Governor of Connecticut in 1854 and Governor in 1857. He was largely interested in the building of the Housatonic and the Connecticut Western roads. He was the father of Alexander L. Holley, the distinguished engineer who died several years ago.

J. W. SHERWIN, who died in Erie, Pa., September 24, was a civil engineer well-known in the West. He was 50 years old; when still a young man, he made the preliminary survey for the old North Missouri Railroad. Subsequently he surveyed the Belleville Branch of the St. Louis, Alton & Terre Haute, and made the first borings and explorations for a bridge over the Mississippi at St. Louis. He was for some time Assistant Superintendent of the Chicago & Alton. He afterwards went to Iowa and was prominent among the settlers of the western part of that State.

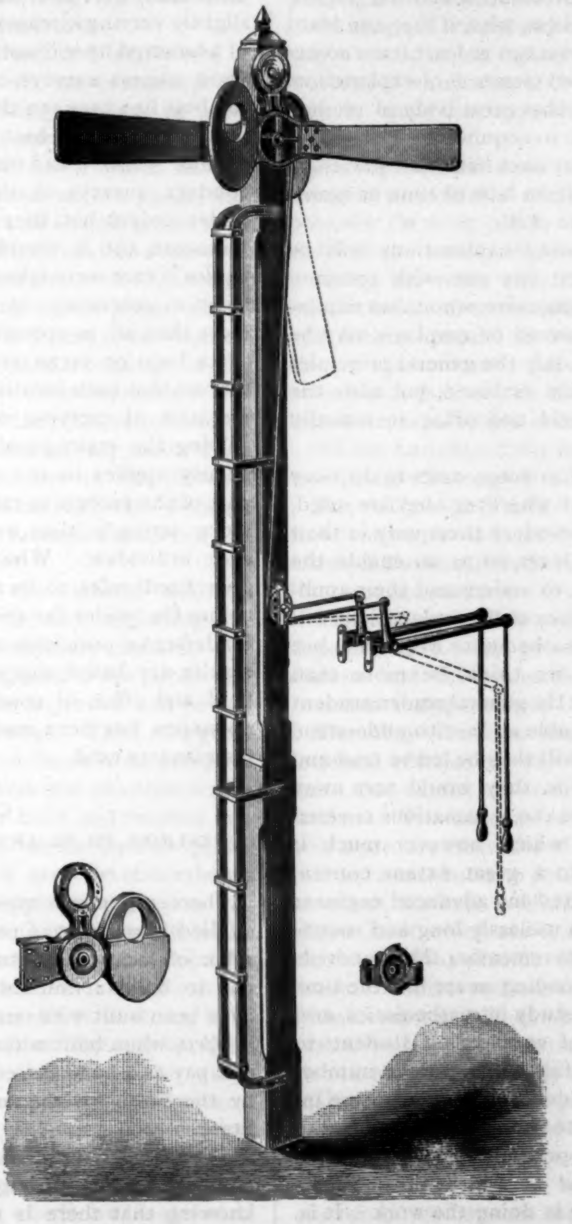
FREDERIC W. VAUGHAN, President of the Louisville Bridge and Iron Company, died recently at Louisville, Ky. Mr. Vaughan was born at Warren, Me., June 6, 1844, graduated at the Rensselaer Polytechnic Institute in the Class of 1863, and was elected a member of the American Society of Civil Engineers in 1869. He went to Nashville during the war as Assistant Engineer on Government railways and has since been prominently identified with much of the bridge construction of the South. He served as Principal Assistant to Mr. Albert Fink on the first bridge across the Ohio at Louisville, and has been closely connected with the Louisville Bridge & Iron Company ever since. In addition to the presidency of this company he held at the time of his death the positions of Chief Engineer of the Henderson Bridge Company and Consulting Engineer of the Louisville & Nashville Railroad.

HON. L. A. SENECAL, who died in Montreal, October 11, was for many years one of the most prominent railroad men in Canada. As a financier and politician he rose to the highest rank. He had been the President of the Richelieu & Ontario Navigation Company for years, and had made of that line one of the most extensive fresh-water routes in the world. He was General Superintendent of Government railways, and President of the North Shore Railway Company and of the Montreal City Passenger Railway Company. In 1857 he opened the Yamaska River to navigation from Sorel to St. Aime, and the St. Francis River from St. Francis. Among the railroads which he constructed are the following: Richelieu, Drummond & Arthabaska; Laurentian Railway; St. Eustache Railway; Berthier Railway; Lanoraie, Joliette & Valois; L'Assomption Railway, and the Basse Laurentides Railway. He built and worked the railroad over the ice on the St. Lawrence from Montreal to Longueuil.

Under his management the Richelieu line was extended from Hamilton and Toronto to Chicoutimi, a distance of nearly 1,000 miles. He was an active politician, and for several years was said to control the provincial Legislature of Quebec.

Harrington's Semaphore.

THE engraving represents an improved semaphore signal, designed by Mr. S. H. Harrington, Mechanical Engineer of the Pittsburgh, Cincinnati & St. Louis Railroad, and which is made by the Barney & Smith Manufacturing Company, of Dayton, Ohio.



HARRINGTON'S SEMAPHORE.

Without any strikingly novel features, the semaphore is so designed as to cheapen its cost, and reduce it to a practical form. The signal lamp is placed on top of the post, as shown. The semaphore blades are attached to a casting, shown separately on the left side of the engraving. This casting has two openings; one of them shown on top has a red lense, and the other is open. When the blade is in the position represented at the top of the engraving, the red lense comes in front of the lamp; when the blade is down, as shown by the dotted lines, the other opening comes in front of the lamp, which then shows a white light. The same pattern of casting can be used for each of the semaphore blades, and the same lamp answers for both.

The casting has a sheave on it, shown in the left side of the engraving, around which a wire rope is wound which raises the signal. The levers with which it is operated are shown in the engraving. These can, of course, be located in any convenient position.

This signal is now in use on the Pan-Handle, the Cincinnati, Hamilton & Dayton, the Bee Line, the Louisville & Nashville, the New York, Lake Erie & Western, the Fort Wayne and other roads, and it has the merit of being simple, practical and cheap.

Contributions.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

INTRODUCTION.

The object of this book is not alone to furnish additional data and information to our educated engineers, men who have the higher mathematics at their fingers' ends and the leisure to use them, who, if they can learn nothing else from what follows, can at least learn something, we hope, of simplicity and clearness of explanation. This book is written also for that great body of readers who have never had a chance to acquire any knowledge of higher mathematics, or, if they once had this knowledge, have long since forgotten it from lack of time or necessity of making any practical use of it.

It is hoped that the following explanations will be made so plain and simple that any one with common sense and a common-school education who takes any interest in railroads, either as owner or employé, may be able to fully understand not only the general principles upon which a Railroad Location is based, but also the methods used both in the field and office in actually carrying on the work.

It will be found impossible in some cases to do away entirely with mathematics, but wherever they are used, much care will be taken to introduce them only in their most simple and elementary form, so as to enable the reader, with very slight study, to understand their application at once. Undoubtedly many of the explanations will be much longer than if more mathematics were used, but this lack of conciseness will, we think, be more than counterbalanced by the fact that the general reader, student and ordinary engineer will be able at once to understand what we are explaining and will thus be led to read and study the following pages, while they would turn away without making an effort, were the explanations covered with a mathematical coating which, however much it might shorten them, would, to a great extent, conceal them. Therefore let the educated and advanced engineer excuse what appears to him a uselessly long and roundabout explanation, and let him remember that hundreds of our best engineers in Railroading never had the time or opportunity for advanced study in mathematics, and that there is a large number of engineering students to whom this book may prove useful; while more in number than all these is that multitude of people who are interested in whatever pertains to railroads, and who may like to understand the general principles upon which the location of a railroad is based as well as the methods employed in the field and office in doing the work. It is, therefore, for these last two classes that this book is written, and it is the hope of the author that they will find all the questions so clearly explained that, with very little study, they may be able to understand fully all the problems presented, and thus acquire a full knowledge of the fundamental principles of Railroad Location.

One word more before we finish this Introduction:

LOCATING ENGINEERS ARE BORN, NOT MADE.

Some eminent authors on this subject have denied this fact, claiming that, with but ordinary powers of observation, anyone by proper attention to set rules could make a good locating engineer. No one can make a good locator of himself any more than he can make an artist or musician. It must be born in him. Then, if he has this gift or talent, hard study and constant practice will bring him each day nearer and nearer perfection. But without this natural talent, or, as it is sometimes technically called, "eye for country," he may study and memorize all that is written on the subject in the shape of rules or explanations and may practice in the field continually; let him be put into a new country under slightly varying circumstances, and ninety-nine times out of a hundred he will not only waste much time and money upon useless surveys, but in the end will have far from the best line between the given points. Men of this kind usually make the best of assistants. They are hard and faithful workers and obey orders to the letter. They can conduct surveys in the best manner where they act under orders, but they should never be found on reconnoissance, and it would be economy for all railway companies if care were taken that these men never conducted location—economy in the location, construction and, more than all, in operation.

As location is an art and not an acquired quality, it follows that each locating engineer has his own individual methods of carrying on the details of the work and solving the many problems that arise. This more particularly applies to the reconnoissance than to any other part of the process of railroad location, as in that is shown more strongly than anywhere else, the personality of each individual. What we propose, therefore, is not to give fixed rules to be applied in all cases, but to place before the reader the results which are required and the fnndamental principles upon which the obtaining of these results are based, together with the methods used in the field and office of conducting the work after the reconnoissance has been made, and a full descripton of all the instruments used.

CHAPTER I.

QUESTIONS TO BE ANSWERED BEFORE THE LOCATION BEGINS.

There are many questions which must be carefully studied in regard to a proposed railroad before any of the work of location begins, and the first is whether it will pay to build a railroad at all. In this country, railroads have been built with one of the following objects in view.

First, when built without any regard as to whether they will pay as a business enterprise, as when a road is built by the State for the supposed good of the people of the State.

Second, when a railroad is built parallel to another railroad or running through the same section of country, knowing that there is not enough traffic for both. The only object in this case is to blackmail the already existing railroad.

Third, when built simply to make money out of the construction. That is, when certain men form a railroad company, raise the money to build the road and then let the contracts to themselves at any price for the work they may choose to fix.

Fourth, when built purely as a legitimate business transaction, for the purpose of making money in a legitimate manner by operating the road. It is with this fourth class only that we have to do, where the idea is to make

every dollar do as much work as possible, but also to have all the work done in a first-class manner and to have no false economy. To decide whether the railroad will pay or not, a most careful study must be made of the resources of the country through which it is going to run, both as to the present and future. The terminal points of the railroad, that is, where it shall start from and where it shall run to, are a question, which, as well as No. 1, is seldom left to the engineer but is decided on a broader basis by the Executive Board of the Railroad Company, and thus, under most circumstances, the engineer is relieved of the responsibility of deciding the two most important questions to the future railroad.

Having decided to build a railroad, and also where to build it, as far as the terminal points are concerned, we come next to the question as to what gauge is to be used, whether standard (4 ft. 8½ in.) or narrow (anything less than standard). There are many points which can be urged in favor of both standard and narrow gauge, and indeed some years ago many miles of narrow gauge road were built; but a large part of these lines has since then been changed to standard, because, notwithstanding all that can be said in favor of the narrow gauge, all the advantages that can be claimed are more than counterbalanced by the fact that the standard gauge is the standard; that is, that the majority of the railroads in this country are of that gauge, and this one point of uniformity, is under all ordinary circumstances of very much more importance than any mere difference in the distance between the rails. The gauge of a railroad is the distance between the rails, and should be measured between the inside of the tops of the rails.

Another question is whether the railroad shall be built in a substantial manner in the beginning, or whether it shall be built in a temporary manner, just good enough to allow it to be opened to the public and transact business and afterward be improved and put in first-class condition from its earnings. This, to a great extent, depends upon the ability of the railroad company to raise money. Of course, the first cost of construction is much more when the road is built and finished in a thorough manner in every respect, but the cost of operating the road is much less, and it must be remembered that this cost of operating is an expense that goes on day by day, increasing with the traffic (but not in the same ratio), while the cost of construction is spent once for all, and the only thing to be considered is the interest which has to be paid for the extra amount of money used in construction; and the extra amount that can be spent on construction is the principal, the interest on which would equal the increase in the operating expenses, if this additional amount were not spent on construction. This would be the case if the railroad company could obtain all the money it needed. But, as this very seldom happens, many of our railroads which are to-day substantial lines in every respect, and paying roads also, could never have been built at all, if it had been required to make them first-class in the beginning.

There is one thing, however, that should never be allowed under any circumstances, and that is that this spirit of economy should be carried so far as to in any way endanger human life, as by the use of cheap, weak bridges or inferior and old-fashioned appliances such as hand brakes, stub switches, etc.

No amount of money saved in the location or construction can compensate for one human life lost, and as the railroad companies take and hold what property they need by the "Right of Eminent Domain," for the benefit of the Public, the law should see that no work is permitted which in any way endangers human life, and compel all railroad companies to use the most approved safety appliances. This is meant to apply to those roads doing business in such a way that, by the absence of the most approved appliances, human life is endangered. On a small road, running only a few trains, and those trains at a slow rate of speed, there is really little risk to the passengers or employés with the most rude appliances in the shape of brakes, switches, etc. All the superstructure may also be much lighter on these small roads, but the material of which they are built should be first-class, otherwise it would be impossible to judge in any way of its strength.

Having decided upon the terminal points, the next thing is to carefully study the resources of the country between them in order to form as exact an idea as possible of the amount of future traffic that will probably be done by the road. To do this there must be taken into consideration all the intermediate towns of whatever size, and without regard to whether they are on the probable line of the railroad. All resources, such as water power, mines, etc., that at the time are valueless, owing to the lack of transportation, must be studied with care.

All the business of the future road may be divided into two kinds, "Through Traffic" and "Way Traffic."

The "Through Traffic" is (1) that which goes directly from one terminus to the other; or (2) is carried over parts of two different railroads either from or to the terminal or intermediate stations.

The amount of Through Traffic a railroad may have depends, to a very great extent, upon the terminal stations and the connections it makes there with other routes of transportation.

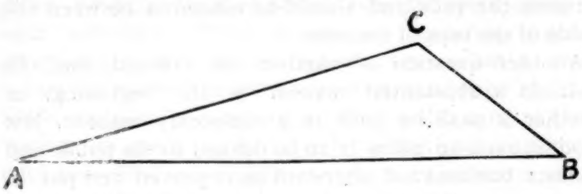
The Way Traffic is that traffic which goes from the terminal stations to the intermediate stations on the same line, or the reverse, and also that between the way stations. The amount of this Way Traffic depends not only upon the resources of the country through which the railroad runs, but also upon the connections made at the terminal stations. Unless the country has resources within itself, which are or can be developed, there will be very little Way Traffic to start with, none going from the intermediate stations outward, and, consequently, very little, comparatively, coming in. The same will be the case, even if we suppose that the intermediate stations are rich in resources, if there are no connections at the terminal stations to carry the products to a market.

The probable traffic of the road is the first question to be studied. This is the business for which the road is built and upon a correct, or at least approximately correct answer to this depends the future success of the proposed railroad. This is very much more the case in America and Mexico than in England and the more populous parts of Europe. In England and Europe, the whole country, so to speak, was under cultivation before the age of railroads, and their introduction simply enlarged the market for already existing products. With us it is exactly the opposite. Three-quarters of our railroads were pushed out into a wilderness far ahead of civilization and cultivation, and the business of these roads was created by them and after they were built. In England and Europe, the

railroads were built because the traffic existed and they were needed. With us the roads were built, and then, from the fact that they were built and offered facilities for transportation, the business which to-day makes them able to pay interest on the cost of construction was made possible and became a fact. It is, of course, evident that, although in England and Europe the traffic existed largely before the introduction of railroads, still, even in those countries, the introduction of railroads has increased that traffic by a hundred fold. The next question to study is the class of the future traffic. That is, of what will the bulk of the business to be done by the road consist. Will it be passengers or freight or both, will the freight be all of one kind, such as coal, mineral or grain, or will it be of a general, mixed character? These questions affect the location, cost of construction and cost of operation. A road that does only one kind of freight business can be built and operated much more cheaply than one that does a mixed businesss. The terminal facilities are much fewer and much simpler, and therefore can approach nearer perfection; only one kind of rolling stock is needed and one class of locomotives. The trains, being all of the same class, run at about the same speed; therefore the track can be put up in just the shape to suit this speed and rolling stock, and thus the expenses of manitenance of way much reduced. The drawback to this kind of business is that it is usually all or nearly all in one direction. We must next consider the question as to the direction in which the bulk of the traffic will have to be carried. Will it all be carried in one direction, or will it be more equally divided, some going in each direction so that the cars can be loaded both ways. If there is only traffic in one direction, the trains going in the opposite direction will only have empty cars to haul, and this return trip will be a loss either to the railroad company or to the shippers. This question is also one which affects very seriously the location of the line and the establishment of the grades; because, if the amount of traffic is the same in both directions, the grades which oppose this traffic must be as nearly the same as possible for the most economical working of the road; while, if the bulk of the traffic is in only one direction so that the returning trains are run light, much steeper grades can be used to oppose these light trains than those which oppose the more heavily loaded ones, and thus much money can often be saved in the cost of construction by so adjusting the grades on the location that their relative resistance to the movement of trains is inversely as the relative amount of the traffic each way. The next question is that of intermediate stations. We have decided upon the terminal stations, and between them are a number of small towns of greater or less importance, which all, to a certain degree, wish the railroad to come to them, and which, to a certain extent, it will pay the railroad to reach. None of them are on the shortest or best line for a railroad between the terminal stations, and it will increase the first cost of construction to build the road to them, besides making it necessary to haul all the through business a longer distance for the same amount of money. (We say a longer distance for the same amount of money, because the rates of through freight to-day are based, in most cases, not upon the actual distance hauled but upon outside circumstances that, within certain limits, have nothing whatsoever to do with the distance hauled.) The question to be decided is, then, whether the extra business to be procured, by thus increasing the actual length of the line will pay the interest on the increased cost of construction due to the increase of length and also the cost to the railroad company of hauling all the other business this extra distance. If the profits from this extra business will pay this additional expense, then build the road to these intermediate towns, but if the profits from this extra business are not enough to pay the additional expense, and there is no reason to believe that there will be sufficient business at any future time, then the road should not be carried to the intermediate towns.

It should be remembered that mere increase of distance by a comparatively small amount, is in itself a very small thing, and that it takes, generally speaking, a very small amount of extra business to pay for the extra length. In the first place, the cost of running an extra mile is a very small proportion of the cost of running the whole distance. Then, under some circumstances, this extra length may be a positive gain, as in the case of passenger traffic, where the rate is so much a mile. If it is a profitable business to carry the passenger 90 miles at a given rate per mile it is more profitable to carry him 100 miles. Often in the case of through lines where the given road forms a link, the longer the link the greater proportion of the whole chain it is, and the greater proportion of fare it will receive. In this question of intermediate towns, we must clearly understand how much the traffic of the road is increased by the addition of one extra station.

We will suppose that we have a railroad running from *A* to *B*, and the traffic of *A* and *B* is the same. Between



A and *B*, is the town *C*, which is a little off to one side; now, if the line runs from *A* to *C*, and from *C* to *B*, and the amount of traffic due to *C* is the same as to *A* and *B*, then the amount of the whole traffic of the road is multiplied by two, and in most actual cases by three, and, as the number of stations is increased, it is a safe rule to say that the traffic of the road will increase by the number of stations, minus one, multiplied by three. This, of course, supposes that each station shall have an equal amount of traffic. According to the above rule, if we increase the number of stations to six, we multiply the traffic by 15. This rule would apply exactly only in ideal cases, but the engineer, and particularly the young engineer, should have all these possible facts firmly fixed in his mind: That a line of railroad can swerve to one side or the other of a right line a good many degrees without materially increasing the distance; that it takes comparatively a very small amount of extra traffic to pay for this extra length; that in many cases this extra length is a direct gain to the railroad. It may be, however, that sometimes, where this extra length is a gain to the railroad, it is a loss to the shipper and consequently is bad policy. Unless there are urgent reasons for increasing the length of a railroad line, such as intermediate stations or topographical obstacles, the length should never be increased simply that a larger amount may be charged for transportation. In these days of competition and multiplicity

of railroads, this would be a most dangerous policy for a company, for the reason that where a line of railroad between two points is longer than there is any necessity for (if those terminal points are of any importance from a business standpoint), it is very certain that a shorter and better line will be built which, for the same rates, can do the business at a greater profit.

In considering the question of branch lines, always remember that, in themselves, branches are very seldom profitable. Unless there are very imperative reasons, why the main line should not be carried through the towns, branches should never be built. But when and where they are built, the only way they pay is in connection with the main line. There are cases where a branch pays in itself, but it is only when it is in such a location and under such condititions that it amounts to a main line. In thus speaking of branch lines, we mean those which are built for ordinary business and not branches which are built for special purposes, such as those running to coal mines, lumber or flour mills, where the business is all of one class, and the probable amount of it can be very exactly estimated. If such special branches do not pay in themselves, it is simply from lack of judgment in the estimates made as to the future traffic.

Another question to be studied before the location is made is the probable cost of the right of way. The importance of this question varies as to the locality in which the railroad is to be. In a wild, unsettled country, the land necessary can usually be had for nothing, while in thickly settled countries where land is valuable, the land for right of way becomes one of the greatest items of expense. This is plainly seen in the great difference there has been in cost of the right of way in England and in this country.

In England the average paid for land, including that used for shops, stations, etc., is £4 000, or nearly $20,000 per mile, while with us the average per mile has been less than $1,000. When possible it is a good plan to let it be understood that the building of the railroad to certain places depends greatly upon the price which will have to be paid for the right of way; not that the railroad company wishes to get the land for any less than a fair price, but simply that it wishes to get it for a fair price and will not be subjected to extortion.

It is strange how the business honor and rectitude of men disappears when dealing with railroads in general, and particularly in the regard to the right of way.

Men who would be shocked at any intimation that they would lie, will deliberately swear that their land is worth ten times as much as they ever thought it was, if a railroad company wishes to buy it. Even when the company will not submit to this extreme extortion and pay the owner the price he asks for the land, and demands a commission to settle the price that shall be paid, it is but a sorry remedy. The commission is appointed from among the friends and neighbors of the land-owner, who are all prejudiced against the railroad and consider it so much in their favor if they can make the company pay well. The company has to pay all the expenses of the commission and then be cheated by it.

Why this purchase of the necessary land by a railroad company should have to be conducted in a manner so contrary to general business principles one cannot understand. A railroad company should be obliged to pay a man a most exorbitant price for improving his property ten-fold, for no one can now deny that, upon general principles, all property is improved by a railroad. There are, of course, exceptions to this rule, but these exceptions usually get exceptional payment.

The state of the money market must be considered before the work of location begins. This question does not now refer so much to the power of the company to raise money, due to its financial standing, as to whether money is scarce or not; whether capitalists, great or small, are seeking investments for their money. There are times when everything is on a "boom," and when money can be had for any scheme for almost the mere asking, and other times when, no matter how solid the scheme is, money can only be procured by paying a very high rate of interest.

The money used in building a railroad has generally been raised in two ways:

1. By issuing bonds and selling them in the public market.

2. By issuing and selling stock. (This method has been for some past falling into disuse.)

The bonds are simply a mortgage for a specified amount upon the property of the railroad company. This mortgage runs for a specified length of time and has a specified annual interest. When this interest becomes due and is not paid, the mortgage can be foreclosed the same as any other mortgage. When the specified term of the mortgage expires, the principal must be paid.

In order to protect the small bondholders, railroad mortgages can usually be foreclosed by the vote of a portion of the holders.

The stock differs from the bonds in the fact that there is no stated amount of interest to be paid on it, but that whatever moneys from the receipts of the road remain over and above the expenses and interest on the bonds shall be divided proportionally among the stockholders in the shape of dividends. The stock also differs from the bonds in not constituting any lien on the property of the railroad company, and if the company goes into bankruptcy, the stock becomes worthless, and the holders of it lose whatever they have paid for it. The stockholders are simply in the position of the man who owns the equity of redemption on a mortgaged farm.

Now, if there is very little money seeking investment, and the future prospects of the road are in any way doubtful, either on account of the lack of resources in the country through which it runs, or on account of the men at the head of the enterprise, the bonds and stocks must be sold at a great discount, and the liabilities of the company made very large in proportion to the amount of actual money it has at its disposal.

This question should therefore be studied with much care, in order that, after the work has once been commenced, it will not have to be stopped on account of lack of funds, and also that when it is finished the debt may not be so large that the road will never be able to pay a fair rate of interest.

Of late years the practice has grown up of building roads entirely from the sale of bonds, the stock being either given as a bonus with the bonds, or, more often, kept by the projectors for their own benefit. In the latter case the control and management of the road remain with parties who have contributed little or no money, while the real owners have no voice; a condition of affairs

which is not desirable, and which has led to many abuses.

The state of the material market is usually of less importance to the railroad company than the state of the money market, for in these days of cheap and rapid transportation, the markets of the whole world compete at every point, and, under all ordinary circumstances, material can always be purchased at a fair price. Still, the question should be studied with care, not only as to what the material will cost at the factory, but also as to what it will cost at the point where it is to be used. In new and uncivilized countries this last is often the most important question.

In Mexico, for example, at the time of the building of the railroad from Vera Cruz to the City of Mexico, it cost $75 per ton to haul the rails from Vera Cruz to the City of Mexico over the mountains, on account of a clause in the concession which required the track-laying to be carried on from both ends at the same time.

In building the Mexican Central the freight on the rails was $24 to $22, delivered in Vera Cruz, from either New-York or Liverpool, and then between $40 and $50 per ton over the Vera Cruz line to the City of Mexico.

The word material, as it is used here, includes not only what is commonly called material, and used in the construction of a railroad, such as rails, ties, bridges, etc., but also all manual labor and superintendency required to do the work and put the material in place. It therefore includes the question of wages and consequently of the supply of labor.

We have thus called attention to the principal points which should be studied and answered with as much exactness as possible, before any of the work on location begins. The manner of solving these questions may differ in each case, and special questions may come up which will require special methods to solve.

However this may be, let the student, engineer or business-man get firmly and clearly fixed in his mind the different points which he must study and the relative bearing and importance of these points, and then, by the use of his own commonsense and his own or some other person's experience, he cannot fail by hard study to arrive at a satisfactory result.

NOTE.—The reader is referred to the following books as the best authorities on the various subjects to be treated of in these articles:

"Manual for Railway Engineers," by George L. Vose.
"The Economic Theory of Location," by A. M. Wel- .ington.
"Railway Curves," by John C. Trautwine.
"Field Engineering," by William H. Searles.
"Topographical Surveying," by J. B. Johnson,
"Elements of Railroading," by Charles Paine.

The author has carefully studied these books and has endeavored to give each credit for anything he has taken directly from it, but in instances when this has been neglected, he begs now to acknowledge his indebtedness to their authors, one and all.

The author also wishes to return thanks to Professor George L. Vose; A. A. Robinson, Second Vice-President, Atchison, Topeka & Santa Fé, and Professor A. E. Burton, of the Massachusetts Institute of Technology, for the kind assistance they have rendered him in collecting some necessary data.

(TO BE CONTINUED.)

HOW ELECTRICITY IS MADE.

BY LIEUTENANT BRADLEY A. FISKE, U. S. N.

FROM the words printed above, it might be inferred that the generation of electricity is a difficult matter and one requiring special apparatus and instruction, but, as a matter of fact, it is much more difficult not to produce electricity than to produce it; and, in refined experiments, the persistent tendency of electricity to obtrude itself where it is not wanted necessitates special means to keep it away and is a distinct source of annoyance to the experimenter. If any two metals, or any two pieces of the same metal, are joined by a wire, or if they are in contact with each other, electricity will be present; and, if both are immersed in water, a current will pass from one to the other; and everybody knows of the trouble caused in mills by the electricity produced by the friction of the belts in passing over the pulleys. The amount produced by these means is small, of course, and is not under good control; yet the generation of electricity in large quantities and in a controllable form has followed, as will be seen, from observation of and experiment with as simple phenomena as these.

For six centuries before Christ it was a matter of general knowledge that amber and jet, if rubbed, would attract light bodies; and the science of electricity remained limited to this knowledge until 1600 A. D., when Dr. Gilbert discovered that the same curious property was possessed by many other bodies besides. It was not, however, until the discoveries of Galvani and Volta, nearly two centuries later and only one century ago, that electrical phenomena began to be regarded as pointing to any practical results; but, when these learned physicists announced the results of their experiments on the nerves and muscles of frogs with different metals in contact, the scientific men awoke to the fact that a wonderful force had been evoked; and since that time, the discoveries and inventions made in electricity have surpassed those made in any other branch of science.

It will be remembered that about 1786 Galvani observed that if two dissimilar metals were brought into contact, respectively, with the nerve and the muscle of a frog's leg and then into contact with each other, a quick convulsive movement of the frog's leg would follow, and that Volta proved afterwards that the electricity thus evidenced was produced not by the frog's leg, but by the contact of the dissimilar metals. In substantiating the truth of his position, he constructed what is now called "Volta's Pile," consisting of discs of zinc and copper in contact with each other and separated by a disc of moist cloth or paper from a similar pair of metals, which were similarly separated in turn from a succeeding pair. The whole pile comprised a large number of such pairs, zinc being at one end of the pile and copper at the other, and when the ends of the pile were connected by a wire, a considerable current was shown to flow from one to the other. Volta also constructed a cell consisting of a strip of zinc and a strip of copper in dilute sulphuric acid, and this cell, in various modified forms, is in use all over the world to-day.

The necessity for any modifications of this cell—known as the simple Voltaic cell—lies in the fact that a very little use will cause it to run down, or to "polarize," as it is usually called. The passage through the cell of the elec-

trical current which it produces causes a chemical action therein, hydrogen being evolved and going to the copper plate, where it forms in a thin film, which not only resists the passage of electricity but also prevents the action of copper as copper, and in most of the numberless batteries invented, the primary object is to destroy the hydrogen as fast as it is evolved.

In the Le Clanché battery, shown in fig. 1, the copper is replaced by a rod of carbon which is surrounded by powdered binoxide of manganese, a substance rich in oxygen. The two are enclosed in a porous jar which, with the zinc rod, stands in a solution of sal-ammoniac. The oxygen in the binoxide attacks the hydrogen, and, if electricity is not generated too fast, it destroys the hydrogen as fast as it is evolved. If, however, electricity—and therefore hydrogen—is generated beyond a certain rate, the battery will run down, or polarize, and will remain in that condition until it has been allowed to rest long enough to give the oxygen time to destroy the accumulation of hydrogen. This fact of requiring frequent rest explains why we use the Le Clanché battery, though cheap, simple and clear, only in such work as ringing bells and operating telephones, where the work is intermittent—not continuous.

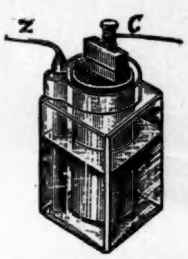


Fig. 1.

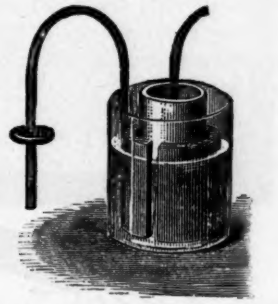


Fig. 2.

For continuous work, such as telegraphing, a battery is evidently required which will not polarize, no matter how long it is used, and for this purpose the Daniell battery—or some modification of it—is employed all over the world. In this cell, shown in fig. 2, a plate of zinc stands in dilute sulphuric acid, in which stands also a porous pot holding a plate of copper in a saturated solution of sulphate of copper, there being also a sort of shallow cup on the rod of the copper plate which holds a few crystals of sulphate of copper, intended to maintain the saturation of the solution. Now, the hydrogen, in passing towards the copper plate, meets the surrounding solution of sulphate of copper, which immediately takes it up, giving up an equivalent amount of copper and depositing it, instead of the hydrogen, at the copper plate—so that hydrogen is destroyed as fast as generated, and polarization is completely prevented. Possibly the cell shown in fig. 3 may be more familiar to most readers than that in fig. 2, but it is merely a modification. It is called the gravity cell, from the fact that the two solutions are kept apart by gravity instead of by a porous pot, the sulphate of zinc, from its smaller density, floating on the sulphate of copper. There are countless forms of voltaic cells, but the Le Clanché and the Daniell are those ordinarily used. Other cells are the Bunsen cell, in which the zinc stands in dilute sulphuric acid while a rod of carbon stands in nitric acid; the Grove, in which a bar of platinum instead of carbon stands in the nitric acid, and the Grenet battery, much used in medical apparatus and shown in fig. 4, in which two plates of carbon stand in a solution of bichromate of potash, there being no action until a plate of zinc is lowered between them by means of the rod shown. This cell gives very strong currents for a short time; but, like the Le Clanché, requires frequent rest; and it requires, in addition, that the zinc be lifted out of the solution during rest.


Fig. 3.

During the early part of this century, many and very costly experiments were made, looking to the employment of electricity on a large scale for running electric lights and working electro-motors; but though the experiments were successful from a scientific view, they failed to bear fruit in a practical way, for the simple reason that the chemicals used, principally the zinc, were so expensive and were consumed so fast, that the cost was altogether out of proportion to the results obtained; and were it not for the discovery of Faraday in 1831, the world might still be without the practical benefits attending the use of the

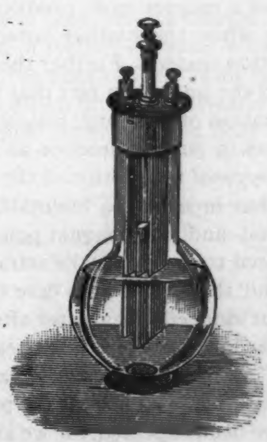


Fig. 4.

electric light and the electric motor on an extensive scale. In coming to Faraday's discovery, it may be well to recall the fact, well known to everybody, that a piece of iron becomes a magnet (called an electro-magnet) while a current of electricity traverses a wire wrapped around it, and that it ceases to be a magnet when the current ceases;

but perhaps it is not so generally known that a simple helix or coil of wire, when traversed by a current, also becomes a magnet, with a north pole at one end and a south pole at the other end, even though there be no iron core, and that even a single loop of wire, such as is shown in

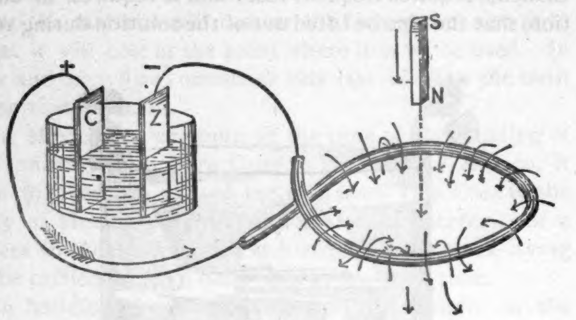


Fig. 5.

fig. 5, becomes under similar circumstances a veritable magnet, and will attract or repel a magnet pole in the vicinity according as the current is in such a direction as to make the adjacent side of the coil a north or a south pole. Now, Faraday made the happy discovery that the converse of this is true; in other words, he found out that if a magnet pole and a closed coil of wire were made to approach each other, a current would immediately traverse the wire, even though there were no battery connected to the wire; and that a current would traverse the wire in the opposite direction if the magnet and the coil were separated. He discovered that, if he used the other pole of the magnet, the directions of these two currents would be interchanged, the approach of the north pole and the coil producing a current in the same direction as the separation of the south pole and the coil and *vice versa*. He discovered that the strength of the current was proportional to the strength of the magnet pole, and that it was proportional also to the rapidity of the motion, a strong current following a rapid motion and a weak current following a slow motion. He discovered that the mere presence of a magnet pole produced no effect, the current lasting while the motion lasted but ceasing as soon as the motion ceased. Further thought and experiment developed the important fact that in all cases of approach or separation of coils and magnet poles, the current induced was in such a direction as to form a pole in the coil which *opposed* the motion of the magnet pole producing it, so that in order to maintain relative motion between the coil and the magnet pole, a considerable force was required to overcome the attraction in the case of separation and the repulsion in case of approach; and since the current induced was greater after a rapid motion than after a slow motion, there was greater resistance to making a rapid motion than to making a slow motion.

Now, this resistance we know at the present day is just what might have been expected, for we know that the production of an electrical current is the production of energy in a certain form and can be obtained only by the expenditure of an equal amount of energy in some other form; so that the energy which Faraday expended in moving the magnet poles against the resistance opposed was simply converted into the electrical energy of the current he evoked.

The announcement of his discovery by Faraday attracted at once the attention not only of pure scientists but of inventors, for its practical value was evident at a glance. It was clear at once that if electricity could be generated by simply moving magnets and coils near each other all the commercial difficulties attending the employment of electricity for lights and motors would vanish, because steam engines as large as necessary could be made to move coils near large magnets; and since the cost of the electricity would depend principally upon the cost of the coal for running the engine, it could be cheaply produced, for the reason that coal was many times cheaper than zinc, and contained, besides, about six times as much heat, which they knew meant six times as much power to do work.

During the next few years, great was the activity among inventors and electricians, all striving to produce a practical machine for generating electricity in large quantities; but it cannot be said that very valuable results were obtained until the advent, in 1870, of the Gramme machine, which closely resembled a machine previously invented by Pacinnoti, but which, for some reason, had not attracted much attention.

In order to get a clear comprehension of this machine —and in fact of all electric machines—it is absolutely essential to consider a principle laid down by Faraday which may seem difficult at first, but which, once understood, the action of all electric machines becomes immediately apparent.

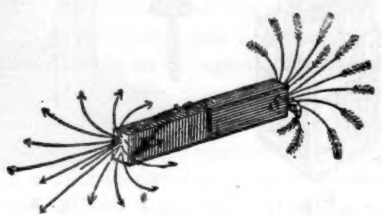


Fig. 5*a*.

Before reciting this principle, it may be well to call to mind the fact that the poles of a magnet reach out into the surrounding air and tend to attract or repel neighboring magnet poles and also induce opposite poles in pieces of soft iron at hand, so that if a piece of soft iron lie near a north magnet pole a south pole will be induced in the side near the magnet pole, and attraction will ensue. The surrounding air may then be conceived to be full of "lines of force" which run, let us say, in the direction in which a north pole, there placed, would tend to move, that is, away from the north pole of the magnet and toward the south pole; and fig. 5 *a* shows a bar magnet with lines of force running from the north pole and into the south pole.

That these lines of force are not purely imaginary, may be easily shown by the simple expedient of sifting fine iron filings upon a piece of card board and placing the poles *N* and *S* beneath, as indicated in fig. 6, when the iron filings will range themselves in lines as shown, radiating from the poles. But it is not only magnet poles which have this capability, for it can be shown by a similar experiment that any wire when traversed by an electric current throws out lines of force and possesses magnetic power, for if held near a magnet pole, it will deflect it to the right or the left, and if passed through a hole in a card-board over which fine iron filings have been sifted, the filings will

arrange themselves in circles, showing that a wire traversed by a current is surrounded by magnetic lines of force which circle about it. If now such a wire be bent into a loop, as in fig. 5, it will be seen that the lines of force combine to run out of one side and into the other, forming a north pole and a south pole, respectively.

Now, such a coil is said to "embrace" these lines of force, and the number of lines of force is proportional to the strength of current; or, which is the same thing, is proportional to the strength of its poles, a strong current and strong poles carrying a greater number of lines of force than a weak current and weak poles.

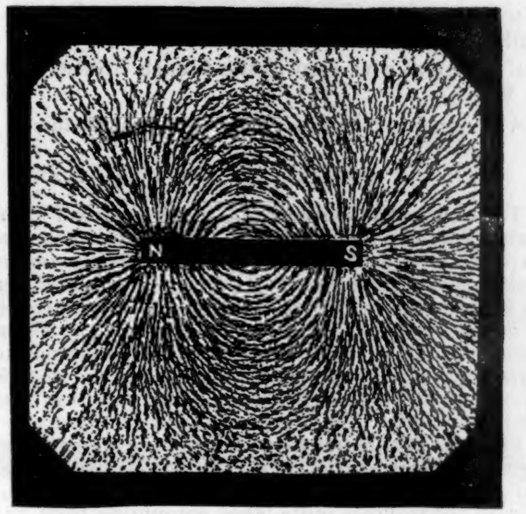


Fig. 6.

But a coil can embrace other lines of force besides those due to its own current; it may embrace also those due to a neighboring magnet pole, the lines of force coming direct from a north pole being usually considered as being positive in direction—or, as sometimes expressed, being positive lines of force, and those from a south pole being negative. In fig. 5, the coil is shown as embracing the lines of force due both to its own current and to the adjacent magnet pole.

We now come logically to a statement of Faraday's principle, which is that *when a conductor is so moved in a magnetic field as to cut the lines of force, a current is set up in the conductor at right angles to the motion.*

But it can be shown that if the wire be bent into a loop, it is possible to so move it that no current will be set up, because the current generated in one side of the coil can be made to oppose that generated in the other side. It is, therefore, necessary to so move the coil that the current generated in one side of the coil will be greater than that generated in the opposite side, and this we see that we can do quite easily by the simple expedient of rotating the coil as shown in fig. 7, for in this case the top of the coil evidently cuts more lines of force in a revolution than the lower part, so that the current generated in the upper part overpowers the weaker opposing current generated in the lower part. A better way to consider this case, however, is to regard the coil as *embracing* a certain number of the lines of force, when it immediately becomes clear that a current is generated in a coil when the number of lines of force which it embraces is *changed*, a current in one direction following a decrease in the number of lines of force embraced, and a current in the opposite direction following an increase. If, also,

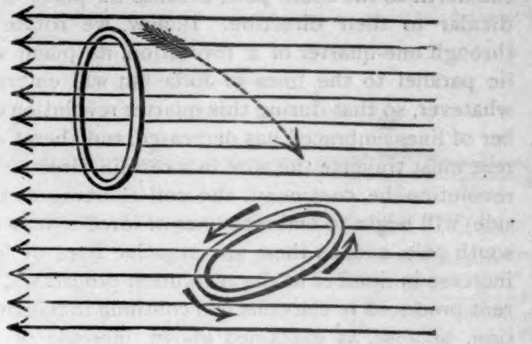


Fig. 7.

a coil be moved as indicated in fig. 8, a current will set up, since, though the coil is not rotated on its axis, it is moved from a field in which positive lines of force enter one side to a field in which negative lines of force enter the same side; and, though the absolute number of lines

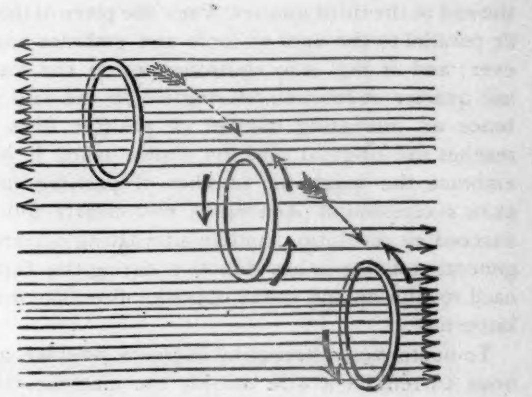


Fig. 8.

may be the same in both cases, a change from positive to negative lines is, in reality, *decrease*, while a change from negative to positive lines of force is an *increase*.

We are in a position now to see clearly that, to make a machine to produce electricity, the only thing necessary

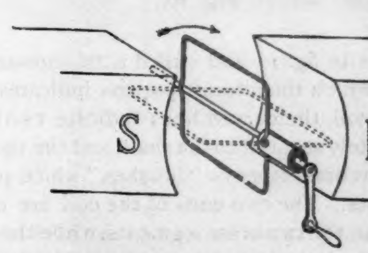


Fig. 9.

is to mount a coil between the poles of a magnet and revolve it; in other words, to make some such apparatus as that shown in fig. 9.

But a difficulty presents itself here, for, as a slight consideration will show, the current produced will be in one direction during one-half a revolution and in the other

direction during the other half. To see this clearly, let us follow the coil through one revolution.

In the position shown, the coil evidently embraces the greatest possible number of lines of force that run from the north to the south pole, because its plane is perpendicular to their direction. If, now, we rotate the coil through one-quarter of a revolution, its plane will then lie parallel to the lines of force but will embrace none whatever, so that during this quarter revolution the number of lines embraced has decreased, and, therefore, a current must traverse the wire in a certain direction. If the revolution be continued, the coil (looking at the same side) will begin to embrace lines of force coming from the south pole, and, as these are negative lines of force and increase in number as the revolution progresses, the current produced in the coils will continue in the same direction, because, as explained above, increase of negative lines of force has the same effect as decrease of positive lines. When the second quarter revolution has been completed the coil will stand in a position the reverse of that shown, and it will embrace (looking at the same side of the coil) the greatest possible number of negative lines. Continuing the revolution, we see that the number of negative lines will at once begin to decrease, so that the current will now be reversed, and this will continue until the end of the third quarter, when the plane of the coil will lie parallel to the lines of force and embrace none whatever; and it will also continue during the fourth and last quarter revolution, during which the coil will embrace an increasing number of positive lines, until it reaches the original position shown, when it will again embrace the maximum number of positive lines. The same succession of phenomena will clearly follow every succeeding revolution, and an alternating current will be generated, being in one direction during the first half of each revolution and in the opposite direction during the latter half.

To make these alternating currents produce a continuous current in a wire outside the machine, the simple

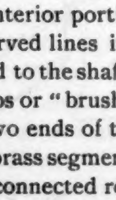


Fig. 10.

device shown in fig. 10 and called a "commutator" was invented, in which the interior portion indicates the shaft carrying the coil, the curved lines indicate two brass segments separately secured to the shaft, and the two straight lines represent brass stops or "brushes," which press upon these segments. The two ends of the coil are connected respectively to the two brass segments, while the two ends of the outside wire are connected respectively to the two brass "brushes;" and, as these brushes are stationary while the shaft revolves, the brushes interchange segments twice in each revolution, so that just as the current coming into one brush from one segment is about to change, the other segment comes under the brush; therefore, the current given to the brush is always in the same direction, though the current in the revolving coil continues to alternate.

(TO BE CONTINUED.)

METALLIC TIES ON EUROPEAN RAILROADS.

THE second question on the programme of the International Railroad Congress at Milan is as follows: "What conclusion can be drawn from the double point of view of economy and of technical success, of the latest results obtained by the use of metallic ties?"

In answer to this question, four documents have been submitted, an analysis of which has been made by M. A. M. Kowalski, Chief Engineer of the Bone-Guelme Line in Algeria. The documents are:

1. A report of the company operating the Netherlands State Railroads.

2. A note from the Eastern Railroad of France.

3. A note from the administration of the Belgian State Railroads.

4. A report, with map, of the French Ministry of Public Works.

A summary of these documents is given below:

1. THE NETHERLANDS STATE RAILROAD.

The note of the Netherlands State Railroad Company gives experience for 22 years. In 1865, this company put on the Deventer-Zwolle line 10,000 metallic ties of the Cosijn system, consisting simply of a rolled iron beam of an H form laid flat, measuring 2.70 meters in length and 20 centimeters in breadth, and weighing 56.7 kilometers each; the rail of iron, weighing 38 kilogrammes to the meter, was placed upon oak blocks raised on this tie and having an inclination of 1 in 20. The rail was fastened simply by bolts. This system is shown in fig. 1.

This tie, although somewhat primitive and not presenting any of the qualities which are now considered essential for metallic ties, has done excellent service. Although the traffic is quite large, amounting from 12 to 16 trains a day, after 22 years of service there still remain in the track 9,547, or 95½ per cent., of the 10,000 originally laid.

In 1880, this company, encouraged by the success of the preceding experiment, decided to undertake a careful study of the question of metallic ties, profiting each year by the results obtained to introduce new improvements. (Some account of the experiments undertaken by this company was given in the RAILROAD AND ENGINEERING JOURNAL for August last, page 365.)

The note furnished by this company gives, in detail, the programme of these experiments, which have resulted from 1881 up to January 1, 1887, in putting in the track of 124,000 metallic ties of 9 different types.

The weight of the ties has been continually increased; from 40 kilogrammes for those used in 1881, which were of rolled iron, it has increased to 50 kilogrammes in 1883, for a steel tie and to 55 kilogrammes in those last tried, which are of steel, rolled to a varying profile and thickness.

The system which the company has finally adopted is that designed by its Chief Engineer of Maintenance of Way, M. Post. This tie is of the type shown in fig. 2. It presents with a few modifications, which practice has caused to be adopted, the following characteristics:

Material, mild steel. Form, section of U reversed, of variable width; the ends bent down. Length, 2.55 to 2.65 meters (8¼ to 8½ ft.). Weight, 50 to 55 kilogrammes (110 to 121 lbs.). Fastenings—bolts and nuts of steel with eccentric heads, giving about 16 millimeters of bearing; stop-washers interposed between the bolts and the nuts. The weight of the fastenings is about 3.5 kilogrammes (7½ lbs.)

Disposition of ties: 10 ties to the length of one 9-meter rail, or 13 to a 12-meter rail; rails weighing from 33.7 to 40 kilogrammes to the meter. Ballast—sand, cinders and gravel.

Weight of locomotives, 50 to 68 tons; maximum weight on the axle, 14 tons; maximum speed of trains, 75 kilometers an hour.

Fig. 1

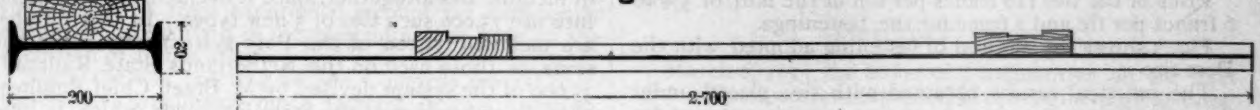


Fig. 2.

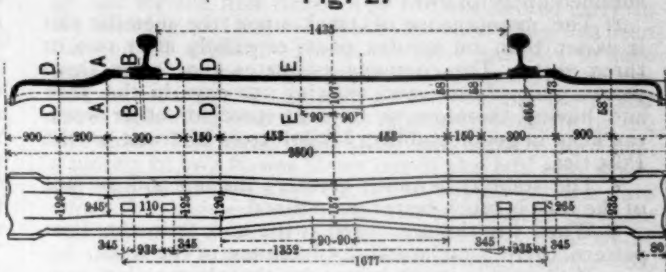


Fig. 3.

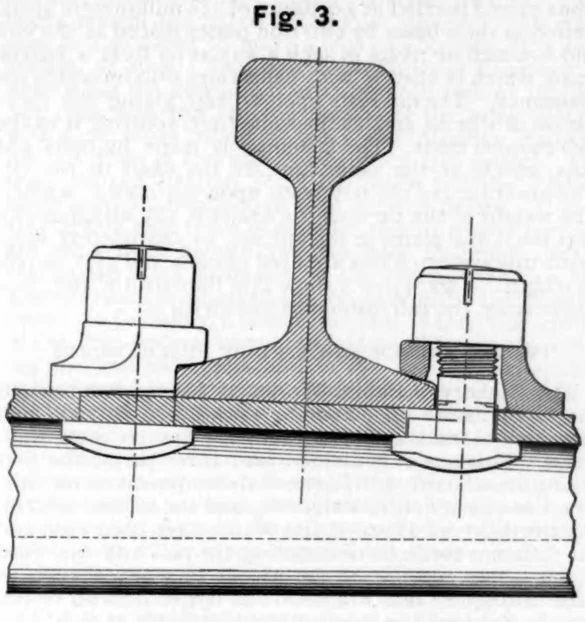
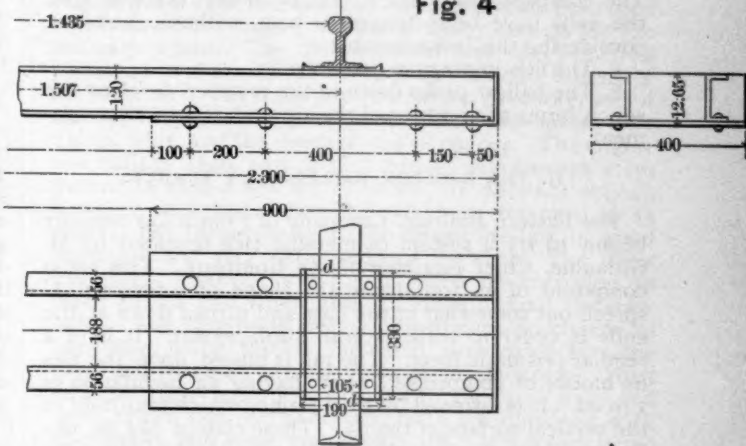


Fig. 4



TYPES OF STEEL TIES USED IN EUROPE.

Fig. 5

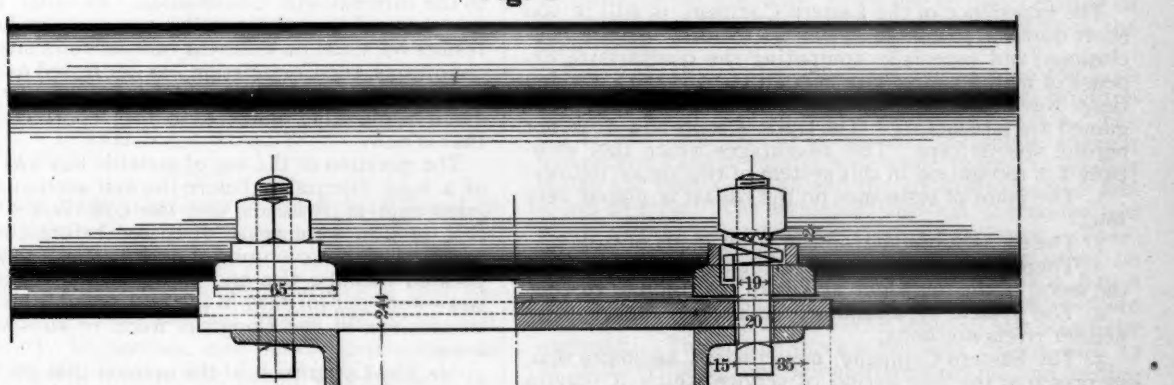
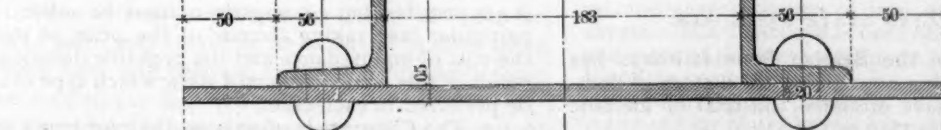


Fig. 6



Maximum radius of curvature, 350 meters (1,148 ft.)
Maximum grade, 0.016.

Price of the ties, 110 francs per ton at the mill, or 5½ to 6 francs per tie and 1 franc for the fastenings.

Fig. 3 shows the method of fastening adopted with the Post tie.

The practical results obtained with ties placed under these conditions are given in the company's note under the form of extensive statistical tables, which can be summed up as follows:

1. The maintenance of track upon the metallic ties is easier than on wooden ones, especially after two or three years. The company estimates that after three years a gang of four men, working 250 days in the year and having, therefore, 50 days to spare for other work, can keep in good condition 8 kilometers of track on the Post ties.

2. The stability is much greater; the line and surface of the rails is much better maintained.

3. When the ties are closed at the end, as in the Post pattern, there is no lateral displacement of the track.

4. Mild steel is much better for ties than rolled iron. The company considers it best to anneal the ties after the ends have been flanged or bent, without, however, considering this indispensable.

5. The fish-joints give good results.

6. The ballast packs down in the reversed bowl or cup which forms the interior of the tie and resists all movement.

II. THE EASTERN RAILROAD OF FRANCE.

The Eastern Railroad Company of France has recently begun to try a system of metallic ties, invented by M. Gillaume, Chief Engineer of the Company. This tie is composed of an iron beam the shape of a reversed U spread out somewhat at the base and turned down at the ends in order to resist lateral displacement. It is of a regular prismatic form. The rail is placed upon the ties on blocks of compressed wood, having an inclination of 1 in 20. It is fastened by steel clamps which take hold of the vertical surface of the tie. These clamps can be unfastened in such a way that the tie may be taken out without moving the rail.

The tie proper weighs 78 kilogrammes; the fastenings, 8.4 kilogrammes, a total of 86.4 kilogrammes (190 lbs.).

The experience of the Eastern Company is still of too short duration to enable its officers to form definite conclusions, and especially computing the comparative expense of maintenance with metallic ties or with wooden ties. Nevertheless, it can already be said that the results gained are satisfactory. The track is solid and does not require special care. The advantages which this company has recognized in this system of ties are as follows:

1. The point of resistance on the ballast is placed very low.

2. The tie accommodates itself to all kinds of ballast.

3. There is no contact between the foot of the rail and the metal of the tie, which avoids all corrosion or rusting.

4. The system of attachment is simple and requires neither rivets nor bolts.

5. The Eastern Company, nevertheless, estimates that, by reason of the long period of service which it obtains from its ties of creosoted oak (a period which is averaged at about 25 years). the substitution of metal for wood does not present any peculiar advantages.

III. THE BELGIAN STATE RAILROADS.

The management of the Belgian State railroads has sent to the Commission a note giving the history of numerous failures which have attended the trial of metallic ties on these roads from 1846 to 1885.

The continued unfavorable results shown by this note would lead one to adopt a conclusion adverse to the use of metallic ties, were it not that the different trials undertaken on this road show that the failures resulted either from inherent faults in the different systems tried or from faults in the material. It may also be said that none of these trials have been continued through periods sufficiently long to give real definite results.

It appears, indeed, that the management of the Belgian State railroads has not seen fit to condemn the principle of metallic ties altogether, since it decided, in 1885, to put into use 75,000 such ties of 3 new types. In this number are included 35,000 of the Post system, very much the same as those used on the Netherlands State Railroad; 35,000 of the system devised by M. Braet, Chief Engineer of track and bridge of the State Railroads, which is very similar to the Post type, but somewhat wider and with deeper flanges; 5,000 of the system devised by M. Bernard, Engineer of Maintenance of the Northern Railroad of Belgium. This third type is composed of two channel irons placed parallel at a distance of 188 millimeters apart, united at their bases by two iron plates placed at the end and fastened by rivets in such a way as to form a hollow trunk which is filled in with ballast and thus increases the resistance. The rail rests upon a chair, giving the inclination of 1 in 20, and, at the same time, securing it to the two channel irons. The fastening is made by bolts and nuts, which, at the same time, fix the chair to the tie. The lower face of the nut rests upon an elastic washer. The weight of the tie with the chairs is 105 kilogrammes (231 lbs.); the plates at the end are 40 centimeters long. With this system, 8 ties are used in each rail of 7 meters in length. Figs. 4 and 5 show this Bernard tie and, on a larger scale, the rail fastenings used with it.

IV. THE FRENCH MINISTRY OF PUBLIC WORKS.

The Ministry of Public Works of France has sent to the Commission an elaborate work by M. Brika, Chief Engineer of track and bridges for the French State Railroads. This report is divided into three parts; the first giving an account of the general development of metallic ties, since their first introduction, and the second describing the different types of ties which have been used and the different methods of fastening the rail, and the third giving some account of the extent to which they have been introduced into France. The larger number of ties used in France have been of the Vautherin type (shown in fig. 6) or modifications of it.

GENERAL CONCLUSIONS.

The documents which have been analyzed as above are the only ones on this question which have been addressed to the International Commission. In order to complete its work and to make possible comparisons between the results obtained on different railroads and under different conditions, the Commission has addressed questions to a number of Managements, but a *résumé* of the answers given in the table annexed to the report contains little that is new.

The question of the use of metallic ties was the subject of a long discussion before the first section of the Congress held at Brussels, and the conclusions reached by that section were again discussed before the full Congress, where the opinions of both parties—those who advocated metallic ties and those who advocated wooden ties—were put forward in the best possible manner. The conclusions of the Congress were, in substance, as follows:

"1. The Congress is of the opinion that track on metallic ties, considered from a technical point of view, can sustain a comparison with track on wooden ties quite as well on lines of the heaviest traffic as on those of light traffic. From the financial point of view no general comparison is yet possible, but a comparison must be made in each particular case, taking account of the price of materials, the cost of maintenance and the probable duration. The result of this comparison will show which type of tie is to be preferred in each case.

"2. The Congress is of opinion that for trunk lines of heavy traffic and for military or strategic lines a metallic tie should be used heavier and more strongly made than that which can be employed on branch and secondary lines, especially when there is no probability that these secondary lines are likely to become traffic lines in the near future. In this case the cost of metallic ties for secondary lines will be very much less than is necessary to expend on the trunk lines.

"In relation to the best form and dimensions of the metallic tie, the Congress is of the opinion that the results obtained from experience are not yet sufficiently conclusive to justify it in recommending one type to the exclusion of all the others."

Since the last meeting of the Congress several companies have manifested much interest in this question. These companies have reported new ties laid of different patterns, either on trial or as an extension of previous use, as follows:

Eastern Railroad of France, on trial, 5,000 of the Paulet system; 10,000 of a type slightly changed from the Vantherin system and 20,000 of the Post system. This company is also about to make a trial of 5,000 ties of a new system, of steel. The Northern Railroad Company of France has put down on trial 15,000 iron ties of the old box type, and has ordered 10,0000 of the same system with some slight modifications. The Algerian Railroad has put down in renewals 20,000 of the Hilf system. The trials on the Belgian State Railroads and the Netherlands State Railroads have been noticed before. It may also be said that trials of metallic ties in small numbers are being made on the Swedish State Railroads, on the Hungarian State Railroads, on the Midland and on the Eastern roads in England and on several of the Spanish lines. In Germany, it is reported that 184,000 ties, mostly of the Post system, have been laid on different lines during the past two years, and in the Argentine Republic (where wood is scarce and costly) 112,000 ties of iron of the inverted U shape have been put in use.

As sub-issues or minor arguments in favor of the use of metallic ties which may be taken into account in deciding upon their use, it is noted that the Paris, Lyons & Mediterranean Company estimates that the use of metallic ties on the Algerian lines has enabled it to save about one-quarter of the labor required for maintenance. The Chief Engineer of this Company estimates the saving at about 500 francs per kilometer per year ($155 per mile). It is also noted that on the short line which a French Company is building in Senegal, on the coast of Africa, it has been found necessary to use metallic ties, as ties of the best oak brought from Europe were destroyed by white ants in less than three months. In these, as in many other cases, however, the question of the use of wood or metal must be decided wholly by local circumstances.

LOCOMOTIVE-BOILER EXPLOSIONS ON BRITISH RAILROADS.

THE reports of the Inspectors of the British Board of Trade have usually been fairly full and complete on locomotive-boiler explosions. Accidents of that class are, indeed, generally of considerable importance in their results, almost invariably causing loss of life, or at least serious injury, to persons, and much destruction of property. They are, moreover, not of very frequent occurrence and do not come to be accepted and passed over as a matter of course, like some other kinds of accidents.

A summary of the Inspectors' reports on the explosions of locomotive boilers, as made to the Board of Trade for a series of years, may therefore be expected to show some interesting facts, and, perhaps, to throw incidentally some light on doubtful or disputed points.

Such a summary is begun below, and will be continued up to the present time in following numbers of the JOURNAL.

The Inspectors' reports, as has been heretofore noted, are made by experts who are continually employed in this work, and who are, moreover, invested by law with power to examine witnesses and use other methods of arriving at the causes of accidents. They possess, therefore, not only an official character, but also the weight attaching to experience and knowledge of the subject of which they treat.

INSPECTORS' REPORTS.

March 6, 1853, the boiler of a locomotive on the London & Northwestern exploded in the engine-shed at Longsight, killing 6 persons who were on or about the engine. The engine had been under repair and was just ready to go out for the first time. The fire was lighted early in the morning, and just before the explosion steam had been blowing off slightly. The safety valve was said to have been set at 70 lbs. The explosion was confined to the rear end of the boiler around the fire-box, the barrel and tubes remaining intact, and its effects were chiefly on the left side. The outer iron shell was entirely torn off; a piece 3 ft. by 4 ft. was blown out of the left side, drawing with it the iron stays out of the copper fire-box, into which they were screwed. The driving-wheel on that side was blown off, the axle breaking at the crank. The whole of the boiler plate, over the crown-sheet of the fire-box, was torn off and doubled up in the form of an S. The engine was a light one and had for several years been used chiefly as a pilot engine, not being heavy enough for the ordinary trains. The boiler barrel was of $\frac{5}{16}$-in. iron plates, 42-in. diameter and 8 ft. long, with 149 tubes, $1\frac{3}{4}$ in. diameter. The outer fire-box (which gave way) was of iron, $\frac{3}{8}$-in. plates and 42 by 50 in. The water-spaces were $2\frac{1}{2}$ in. wide, and the fire-box was of copper. The engine was built in 1840, and in 1842 had 33 new fire-box stays put in; in 1846, a new set of tubes. It does not appear, however, that the fire-box had ever been removed in 13 years. The Inspector found the copper fire-box in good condition and very little reduced by wear. The outer iron shell, however, was found pitted by corrosion in many places and eaten away in rings around the stay-bolts. The stay-bolts were extraordinary specimens of corrosion, being thickly incrusted with oxide in some parts and in others greatly reduced in thickness. Most of these stays remained attached to the iron plate and were drawn out of the copper, but a few remained with the copper, and some were broken off. It was also found that 11 of the tubes were nearly choked with a deposit of sulphate of lime. The Inspector does not think that there was any extraordinary or unusual pressure on the boiler, but believes the explosion to be due to the corrosion of the outer sheet and the weakening of the stays from the same cause.

March 17, 1853, the boiler of a locomotive on the London, Brighton & South Coast road exploded at Brighton while the engine was waiting to go out with a train. The engine had come the day before from the shops, where it had received slight repairs, and while there the fire-box casing had been taken off and the fire-box examined and found all right. The evidence was that the boiler had plenty of water a few minutes before the explosion. There were two safety-valves, one on the dome, the other on the fire-box; both were set at 80 lbs. in the shop, but it is said that the driver had screwed the dome valve down to 100 lbs. The valves were both blowing just before the explosion. The engine was a small tank engine with 12 by 18-in. cylinders, one pair of drivers (66 in.) and leading and trailing wheels 42 in. diameter. The boiler-barrel was 40 in. diameter and 8 ft. long, with 101 tubes, 2 in. diameter. It was built in 1840, had new tubes in 1844 and a new fire-box in 1848. The explosion tore open the barrel, and several pieces of iron were torn out from the sheets. The fire-box was bent out of shape, but not torn, and most of the stays were good. The plates (iron) were found to be generally full $\frac{5}{16}$ in., but in some places were reduced by slight corrosion to $\frac{1}{4}$ in. The boiler was made of four plates carried lengthwise along the boiler and single-riveted. The original thickness of the plates was $\frac{3}{8}$ in. in the barrel and $\frac{7}{16}$ in. in the outer fire-box. The Inspector thinks that the explosion was due to weakening of the plates by corrosion and to excessive pressure; he also thinks that the construction and design of the boiler was not of the best class.

January 8, 1854, the boiler of a locomotive on the Midland Railway exploded near Bristol. The train (freight) had stalled on a grade, and the engine was just preparing

to go on with part of it when the explosion took place. The engineer and fireman hardly heard it, although a loud noise was heard by people some distance away. The boiler ripped open along a line near the top, the dome and part of the shell being torn off and thrown nearly a quarter of a mile away. The engine was about nine years old; it had 16 by 21-in. cylinders and six-coupled wheels, 60 in. diameter. The fire-box heating surface was 72 and the tubes 750 sq. ft. There were two safety-valves, $3\frac{1}{16}$ in. diameter. The Inspector found that the boiler was in good condition, and thought this a clear case of low water and too rapid generation of steam, the top of the fire-box being probably heated red-hot.

In connection with this accident the Inspector adds: "In considering the explosion I was led to make some experiments to determine what is the smallest aperture requisite for a safety-valve. In the engine experimented on, the area of the heating surface of the fire-box was 162 sq. ft.; tube surface, 1,757 sq. ft.; making a total of 1,919 sq. ft. The grate area was 25.47 sq. ft. The pressures were shown by a Bourdon pressure gauge. The area of the orifice required to keep the steam in the boiler at a given pressure was:

100 lbs.	0.65 sq. in.
80 "	0.75 "
60 "	1.06 "
40 "	1.60 "
20 "	3.00 "

"Hence, the area diminishes as the pressure increases. I have assumed the following formula from these results, in which is included the grate area (G), the fire-box heating surface (S), the pressure of steam (P) and a constant quantity (C) derived from these experiments. I have omitted the tube heating surface, because the experiments were made when the engine was at rest and the tube surface comparatively inactive; besides, the safety-valves are intended to provide for the safety of a boiler at rest. Then, if D=the diameter of aperture of valve, the formula will be:

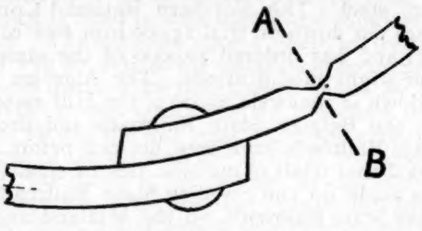
$$D = \frac{S}{PG} \times C$$

"If it be assumed that the valve is lifted $\frac{1}{16}$ in. to admit of the escape of steam, and making use of the data derived from the experiments; and if D be in inches, S and G in feet and P in pounds, the constant C may be taken as 51."

February 7, 1825, the boiler of the engine *Actæon* on the Great Western Railway exploded at Gloucester. The train had stopped at that station, and the engine had put two cars on a siding and was backing up to the train when the explosion took place; the engineer had just shut off steam. The effect of the explosion was to blow off both safety valves, throwing them some 90 ft. away. The iron ring of the foot-stay, weighing about 100 lbs. was thrown 900 ft. and then broke through the wall of a house. The bottom half of the boiler barrel was forced down and broke the driving-axle, while the upper half of the barrel was blown off in one piece, which measured about $8\frac{1}{2}$ by $6\frac{1}{2}$ ft. and weighed nearly 700 lbs. The engine was built in 1841 and was thoroughly overhauled and new tubes put in in 1850. The mileage with the first set of tubes was 150,939; with the second, 106,433. The barrel of the boiler was 8 ft. 6 in. long and was of $\frac{5}{16}$-in. iron in four plates, each about 2 ft. wide, bent lengthwise around the cylinder, but not breaking joints. An examination showed the inside of the bottom plates to be deeply pitted with many small indentations, and along the seam on the right-hand side there was a deep channel eaten away, reducing the thickness of the plate at some points to 0.1 in. As the explosion started at this point, the conclusion was reached that the explosion was caused by the plate being so much reduced in thickness that it was no longer able to withstand the pressure.

This case being referred to Professor Tyndall for his opinion, he replied that the corrosion was very probably due to electric action caused by the iron shell and brass tubes. From the action of this voltaic couple, some decomposition of the water would take place, hydrogen being liberated against the brass and oxygen (acid also, if the water contained salts in solution) against the iron plates. This action, though feeble, would, if continued for several years, be sufficient to explain the corrosion of the plates.

April 5, 1855, the boiler of a locomotive on the Caledonian road exploded while the engine was standing in the shed at Greenock. The engine was seven years old and had run about 227,000 miles in all; the boiler barrel was 42 in. diameter and 10 ft. long, of $\frac{3}{8}$-in. iron, in three plates, each forming a ring, and the rivet lines breaking joints. The engine was lifted by the explosion and thrown over on its side; two men in the shed were scalded. The boiler gave way near the bottom, where there was a line of corrosion very similar to that described in the *Actæon* case above. The appearance of the plate in section is shown in the accompanying diagram, in which



A B is the line of fracture. As far as could be seen the bottom of the boiler was badly pitted. The remarkable point in this case was that there was a line of indentation or corrosion on the outside of the plate, corresponding to that on the inside. The explosion was attributed to the weakening of the plate by corrosion.

April 5, 1855, the boiler of a locomotive on the London & Northwestern exploded in the shed at Rugby. The entire cylindrical cover was torn off, one piece, weighing 1,000 lbs., being thrown a distance of 750 ft. The boiler, so far as could be ascertained, was in good order and the iron of good quality. The only cause for the explosion that could be ascertained was that a careless or ignorant helper in the shed had screwed down the sa ety-valve, allowing the pressure in the boiler to become excessive. The foreman in the shed was censured for allowing such a thing to be done.

July 14, 1855, a locomotive on the North London Railway exploded its boiler while standing at the Camden Town Station. The barrel of the boiler was torn off, leaving the tubes exposed. The examination showed that the throat-sheet, connecting the barrel with the outside fire-box, was very defective, showing signs of bad welding, and that this plate had been further damaged by bending into shape. The plate was $\frac{3}{8}$ in. thick, and the explosion was undoubtedly due to its failure.

July 2, 1855, the boiler of a six-wheel-coupled freight engine on the South Yorkshire line exploded while the engine was standing at Aldam, or, to describe it more correctly, the crown-sheet of the fire-box collapsed. From examination, it appeared that this was a case of low water, the crown-sheet failing because of overheating.

April 7, 1856, the boiler of a locomotive on the Caledonian line exploded when the engine was near Carlisle. The engine-driver and fireman were killed. This was the rare case of a boiler exploding while the engine was running. The crown-sheet of the fire-box gave way, and the engine was lifted up from the track and turned over six times. As both men on the engine were killed and the engine itself almost completely demolished, the examination into this case was attended with difficulties. The conclusion finally reached was that there was excessive pressure, probably due to the fire-box crown becoming red-hot on account of low water, and the consequent sudden evolution of a large volume of steam of high pressure.

November 11, 1856, a locomotive on the Blyth & Tyne road exploded its boiler while standing in the yard. The engine was a very old one, used for shifting, and the boiler was of an antiquated pattern with a return flue and combustion chamber. It was probably a case of old age and complete wearing out.

January 19, 1857, the boiler of a locomotive attached to a ballast train on the Lancashire & Yorkshire road exploded while the train was standing on the track near

Sough. Nearly the whole of the segmental portion of the back end was blown out, tearing out 9 of the $\frac{7}{8}$-in. stay-bolts which attached the back sheet to the fire-box. The sheet which gave way was originally $\frac{3}{8}$ in. thick and was worn down to $\frac{5}{16}$ in. There was also evidence that the longitudinal stays were inoperative. The original condition of the fastenings of these stays is shown in fig. 1

Fig. 2.

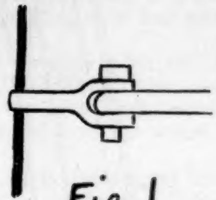


Fig. 1

herewith, but after the explosion they were found extended in the fork, as shown in fig. 2, and very much corroded. The explosion, however, was probably chiefly due to the worn and weak condition of the sheet.

March 6, 1857, the boiler of a shifting engine on the Midland line exploded in the yard at Birmingham. The external shell was torn into large fragments, some of which were thrown 150 ft.; one of them passed through the roof of a building and killed a workman there. This explosion was attributed to corrosion of the sheet, which was very apparent in the fragments.

April 9, 1857, the boiler of an engine on the Belfast & Ballymena road exploded in the yard at Belfast, just after it had coupled on to a train. In this case the fire-box collapsed, the crown-sheet being forced down against the tube-sheet, and the side and back sheets being torn away from the stay-bolts and doubled up; the outer back sheet, with the fire-door, was blown completely away. The crown-bars were 8 in number, $4\frac{1}{2}$ by 2 in.; none of them were broken. One-half of them were attached to the external crown-sheet by hanging stays at each end; these retained their position, the stay-bolts being drawn out from the copper sheet. This was an undoubted case of low water and consequent overheating of the copper plates, with a sudden increase of steam pressure.

November 24, 1857, the boiler of a locomotive on the Southeastern road exploded as the engine was standing at the Greenwich Station, just ready to start. The crown-sheet of the fire-box was ripped along the line of the rivets, the rent extending along the side-plates. The engine was lifted up and thrown across the track. The exact age of the engine was unknown, but a new fire-box and tubes were put in in 1844 and new tubes again in 1854. The copper crown-sheet, originally $\frac{3}{8}$ in. thick, was worn down to $\frac{3}{16}$ in., and the Inspector believes that the sheet failed from weakness, although the boiler pressure seems to have been only 65 lbs.

In this year's report, the Inspector makes the following general remarks: "In accounting for the effects of boiler explosions two facts appear generally to be lost sight of; the first is that after a rupture or rent is once made in the shell of a boiler a much less force is required to extend or continue it than the initial force producing the rupture. Therefore, when high-pressure steam forces for itself an opening through an attenuated part of the boiler plate, the same, or a less, pressure of steam will continue the rent through a part of the plate which may have suffered no attenuation. I would illustrate this by referring to the resistance which is met with in attempting to thrust the finger through a sheet of writing paper, which is considerable, but once the finger is through the whole hand passes without experiencing any further resistance.

"The second fact is that of the cumulative force of steam from its continuous action, as in a rocket. This is generally exhibited where the rupture occurs in the fire-box end of the boiler. The steam then continuously escaping drives the engine horizontally in an opposite direction, or, frequently, it mounts into the air and is carried a considerable distance, as in the Ballymena explosion, in one on the Caledonian Railway, near Carlisle, and in several other cases."

The earlier reports of explosions, while in many cases carefully made and well considered, are hardly so full or so interesting as those which will be found in later years, when the reports are accompanied by sketches and diagrams illustrating points in boiler construction. These sketches will be reproduced in their proper order.

(*To be continued.*)

STEAM FERRIES ON THE DANISH STATE RAILROADS.

(Abstract of note in the *Revue Générale des Chemins de Fer.*)

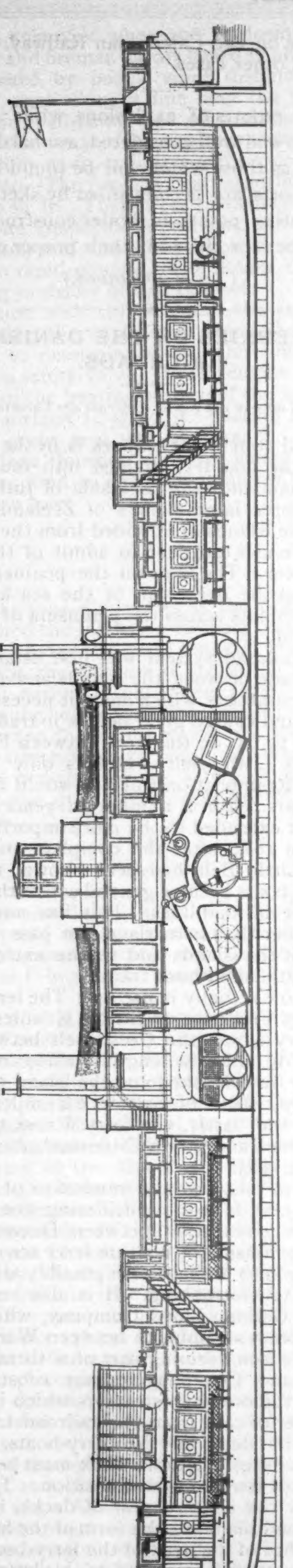
THE railroad system of Denmark is, by the geographical situation of the country, divided into four parts; the lines on the mainland (the peninsula of Jutland) and the lines on the three large islands of Zeeland, Funen and Falster. These islands are divided from the mainland by straits too wide and too deep to admit of the possibility of bridging them. The lines on the peninsula again are obliged to cross the deep arm of the sea known as the Limfiord, which cuts across the peninsula of Jutland near its northern end.

When the railroad system was first established, connection was made between the islands and the mainland by ordinary steamboats, which made it necessary to transfer all freight and caused great delays in traffic. In 1872, it was decided to try, on the ferry between Frederica and Strib across the Little Belt, which is only $1\frac{1}{2}$ miles in width, a large steamboat on which it would be possible to carry loaded cars. For a number of years this kind of service was not extended to the more important transfers. It is only since 1883, after the complete success of the ferry on the Little Belt had been shown, that the use of steam ferry-boats became general across the straits and on the different railroad lines. This has now been done in such a manner that a carriage can pass from Copenhagen to any of the islands and to the extremity of the peninsula of Jutland without transfer.

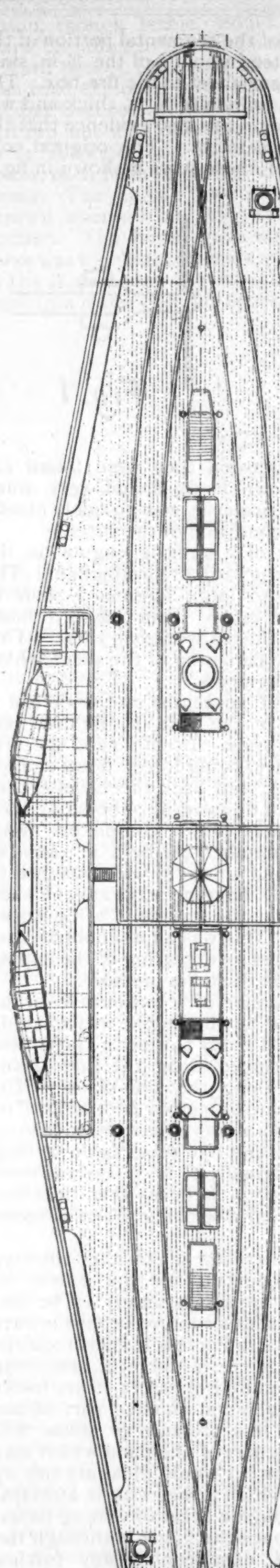
The ferries now actually in use are: The ferry across the Little Belt from Frederica to Strib, $1\frac{1}{2}$ miles, mentioned above; the ferry across the Great Belt between Nyborg aod Korsor, $16\frac{1}{2}$ miles in length, opened in November, 1883; the ferry from Masnedo on the island of Zeeland to Orehovd on the island of Falster, $2\frac{1}{4}$ miles, opened in January, 1884, and, lastly, the ferry across the Limfiord between Oddesund and South Oddesund, about $1\frac{1}{4}$ miles, opened in June, 1885.

In addition to this, a joint commission of Danish and Swedish engineers is now considering the question of completing the connection between Denmark and the Scandanavian peninsula by a steam ferry across the sound from Copenhagen to Malmo, with possibly also one from Frederikshavn to Gottenborg. It is also very probable that the North German Lloyd Company, which has now a service of express steamboats between Warnemunde in Prussia and Gjedson, forming part of a through line between Berlin and Copenhagen, may substitute steam ferry-boats for the ordinary steamers which it now uses.

In the transfer of cars from the railroad tracks to the tracks upon the deck of the ferry-boats, a movable landing-stage is necessary, and a dock must be used which will hold the boat itself in a fixed position. This has been provided for by the construction of decks, in which, by means of piles and planking, the form of the landing place is adjusted to that of the deck of the ferry-boat, while the movable landing stage is provided by a platform or dock supported by iron trusses and resting at one extremity on pivots and supported at the other end by heavy chains, hung from an iron truss or bridge. These supporting chains pass over pulleys on the truss and are carried thence to windlasses, by means of which the bridge can be raised and lowered. In the landing place at Nyborg, on the Great Belt, which is similar to all the others, the



LONGITUDINAL SECTION.



DECK PLAN.

STEAM FERRY-BOAT "NYBORG," DANISH STATE RAILROAD.

landing stage can be raised from an angle of 4° below the horizontal to one of 6° above; the stage being 18¼ meters in length, these extreme inclinations vary from a descending grade of 7½ per cent. to an ascent of 10 per cent. The cars are hauled up and down these inclined planes by means of a cable operated by a steam capstan on the deck of the boat. The dock and landing stage are so arranged, and the attachments are so convenient, that a steamer is brought into position in a very short time and can be fully loaded with cars in less than 10 minutes.

The form of the dock and the arrangement of the landing stage does not essentially differ from those used at the ferries on the Hudson River at New York, except in the substitution, to a great extent, of iron for wood in the construction.

The passage of the Great Belt, which is the longest ferry in use (16½ miles), is effected by two steamers, the *Nyborg* and the *Korsor*, which were designed by M. K. Neilson, Director of Naval Construction, and which were built in the Kockum ship-yard at Malmo in Sweden. A third ferry-boat of the same model is now being built by Burmeister & Wain at Copenhagen. The accompanying illustrations are a longitudinal section, a deck-plan and a cross section of one of these boats.

The hulls of these boats are of steel plates, and their construction is necessarily very solid, as they have to resist the bad weather to which they are often exposed in crossing the Great Belt.

Besides the ordinary keel, the hull carries two false or lateral keels in order to increase the stability. The bottom of the boat is nearly flat, as shown. It is necessary, in fact, that, with the load placed entirely on the deck, these boats should have much more stability than an ordinary vessel and this has been attained to such a degree that, when one of the tracks on the deck is loaded and the other empty, the inclination of the boat is less than 7°.

In order to increase the stability, the boats are provided with paddle-wheels instead of screws. These wheels are made of Swedish iron and are unusually heavy and strongly formed in order that they may not be injured when the navigation is interrupted by ice. There are two engines of the compound pattern, the four cylinders, two for each engine, acting upon the same shaft. Steam is furnished by four boilers, with corrugated fire-boxes on the Fox system. The dimensions of the engines are: High-pressure cylinder, 33.75 in. diameter; low-pressure cylinders, 63.25 in. diameter; stroke, 54 in. The admission of steam in the high-pressure cylinder can be varied from 0.2 to 0.6 of the stroke.

The principal dimensions of the boats are as follows: Length on deck, 250 ft.; greatest breadth on deck, 34 ft.; breadth over the paddle-wheels, 58 ft. The boats draw 8 ft. of water when unloaded and 9¼ ft. when carrying a full load of about 225 tons. The displacement of water when loaded is 1,295 tons. The engines, the dimensions of which we have given above, will work up to 1,500 H. P., and, with an ordinary load, the speed is 13 knots an hour.

On the deck of the boat are Harfield steam capstans for raising the anchor, steam capstans for hauling cars on board and Muir & Caldwell's steam steering apparatus. The boats are double-enders, with a rudder at each end, which can be fixed in place and serve as a stem; it is, therefore, not necessary to turn them.

The engine-room is lighted by electricity, and, in order to facilitate loading and unloading at night, the decks are lighted by arc electric lamps.

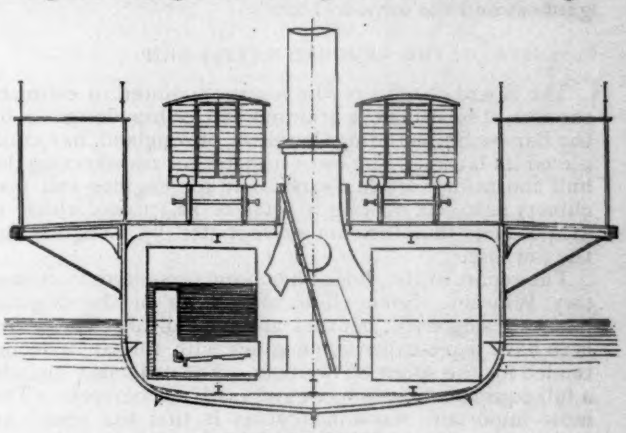
These ferry-boats are abundantly provided with safety apparatus and small boats specially constructed in order to resist the ice.

These ferry-boats are provided with all desirable comforts for travelers. The depth of 16¼ ft. between the deck beams and the bottom timbers allows a height of 10 ft. for the cabins, and they are spacious and well furnished. They are heated and ventilated by special apparatus, the heat being obtained from steam pipes which derive their steam from the large boilers, and the ventilation is effected by blowers which supply fresh air, which is warmed in winter. The impure air is carried off by special shafts. The walls of these cabins are panels of maple and walnut, and the furniture is of maple upholstered with red velvet.

The deck of the ferry-boat shown in the illustration carries two tracks. Each of these tracks can hold 8 freight cars of the pattern in use on the Danish railroads, but it is found that it is not often necessary to take 16 cars at a trip. At each end of the deck the two tracks unite in one which, at the landing, corresponds with that on the landing stage.

When the cars have been run upon the deck they are secured by means of clamps, one end of which is fastened to the buffer and the other to the rail. A screw attached to the clamp permits sufficient tension to be put on to prevent the cars from moving.

Where there is only a single track upon the deck, as in the boats used at the Little Belt ferry, the embarkation of the cars is very easily managed, as they are simply drawn upon the boat by the steam capstans. The use of the two tracks on the larger boats, however, requires some care in manœuvering the cars upon the curves near the ends, as one of the buffers might escape from contact with the buffer on the preceding car. To avoid accidents and derailments, the buffers at the rear of each car are covered during the loading with a strong wooden beam, making a



CROSS SECTION.
STEAM FERRY-BOAT "NYBORG."

continuous surface upon which the buffer of the following car can bear without any danger of slipping out of contact.

As a general rule, these boats carry only the freight-cars, the baggage and the mail cars and special cars (such as the private cars of the royal family and others). Passengers descend from the train, which is run upon a switch close to the dock, and enter the cabin of the boat; when the passage is over they enter another train which waits for them at the landing. The crossing of the Great Belt lasts an hour and a quarter, usually, and delay is very rare, even in bad weather.

The service at the Little Belt is carried on by two smaller ferry-boats named *Hjalmar* and *Ingeborg*, which were built in the Shickatt ship-yards at Elbing in Prussia. The general pattern of these boats is very similar to the larger ones, but they are only 164 ft. in length on deck and are provided with a single track only. The motive power is one compound engine. The speed is about 10 knots an hour; the passage being very much shorter than at the Great Belt, this speed is sufficient, as these smaller boats can transfer during a given time quite as many cars as the larger boats used on the longer ferry.

The service on the other ferries is carried on by boats similar to those used on the Little Belt.

The passage of the Great Belt is rarely interrupted by ice, the sea being open, but in the narrow strait of the Little Belt ice is often driven by wind into masses which freeze together in heavy cakes and cause delays. In order to open the passage a twin-screw boat (the *Valdemar*), with very powerful engines, has been built for the special purpose of breaking up the ice. This boat was not completed until the fall of 1886, and the following winter having been mild she has not been fully tested. It is expected that she will be able to break through ice 6 to 8 in. in thickness.

The steam ferry-boats and other vessels which are used to connect the different Danish lines belong to the Government, and their management is under the charge of a special division of the State railroad management, which is called the Maritime Department. The Chief of this department is Captain F. de Bardenfleth, who is assisted by M. Elmquist, Inspector of Vessels, and John Prior, Inspector of Machinery.

THE NEW WARSHIPS.

THE report of the Secretary of the Navy, to be presented to Congress on its meeting in December, will, it is stated, refer at length to the progress so far made in building a new navy.

For the benefit of the next Congress, it is understood Secretary Whitney will have prepared by the Bureau of Construction and Repairs elaborate descriptions of every vessel now building or the plans for which have been agreed upon. This will include the five great monitors, the cruisers, gun-boats, plans for harbor defense, the armored battle-ship and cruiser, the pneumatic dynamite gunboat and the torpedo-boat.

THE ARMORED BATTLE-SHIP.

The Board of officers which was appointed to estimate the cost of building the armored battle-ship designed by the Barrow Shipbuilding Company, of England, has completed its labors. The last estimates for constructing the hull and fittings are $1,890,000, and for engines and machinery $486,000, making a total of $2,376,000, which is $124,000 less than the sum appropriated by Congress for the purpose.

The report of the Board has been presented to Secretary Whitney. Some slight alterations in the original plans are suggested, but they are not radical. The vessel is to have triple-expansion engines with forced draft intended for the speed of 18 knots. The estimates include a full equipment, such as rigging, sails, anchors, etc. The most important recommendation is that the vessel be built at the Norfolk Navy Yard. It was generally believed that the New York Navy Yard would be selected for the work, but this recommendation, if approved by the Secretary, will probably result in the building of the six-thousand-ton armored cruiser designed by the Navy Department, instead of the battle-ship, at the New York yard. It is believed that it will take about 18 months to build the vessel at Norfolk.

The allowance of $75,000, which was made for the purchase of new plant for this yard, is not large enough, by about $50,000, for a complete equipment, but by the use of temporary sheds it is believed that the work of constructing the great ship can be carried on until Congress provides for the erection of suitable permanent shops. The construction work will be under the immediate direction of Naval Constructor Bowles, and the machine and engine work under that of Chief Engineer Robey.

The following instructions were, September 30, addressed to the Commandant of the New York Navy Yard: "The Department having decided that one of the two sea-going double-bottomed armored vessels appropriated for under the act approved August 3, 1886, shall be built at the yard under your command, the Bureau directs that preparations to that end be immediately made. The report of Assistant Naval Constructor F. T. Bowles to you under date of July 11, and the reports of the Board of which Captain G. C. Remey, U. S. N., was President, ordered by you under date of July 12 and of August 3, 1887, are approved. The Chief of the Bureau of Yards and Docks approves the location of the temporary sheds to cover the tools and machinery, and they will be erected by and at the expense of this Bureau."

To the Commandant of the Norfolk Navy Yard, a letter was addressed, similar in terms to the above, with the exception that it approves the report of Constructor Samuel H. Pook relative to the general arrangements and location of the tools and machinery for the execution of the work at that yard.

COAST AND HARBOR DEFENSE.

In the Naval Appropriation bill passed last March, provision was made for the expenditure of $2,000,000 for floating batteries or rams or other naval structures, to be used for coast and harbor defense. Secretary Whitney appointed a Board of Naval officers to consider the best method of expending this money, and, it is understood, they are ready to submit a report. This report has not been made public, but it is said that its recommendations are about as given below:

Monitors with the heaviest guns that can be mounted are to be the principal reliance for offensive and defensive warfare. About them, as auxiliary means of attack, are to be grouped armored torpedo-boats fitted with rams, sub-aqueous torpedo-boats and the ordinary first-class torpedo-boats.

It will be remembered that the Fortification Board recommended the construction of floating batteries. The unfinished double-turreted monitors, ***Amphitrite***, ***Monadnock***, ***Puritan***, ***Terror*** and ***Miantonomoh***, it was found, would, if finished with modern appliances, furnish the main reliance for coast defense. The improvement in heavy ordnance is such that land fortifications can hardly be relied upon to repel the attack of an invading fleet. Floating batteries would be a necessity, and none have been found more effective than the monitor type, with a turret the very minimum of size as an object to be fired at, while, as a defensive vessel, it can carry the heaviest guns that can be mounted.

The objects against which a naval attack would be directed are the important commercial ports, where vessels in the foreign trade must be protected, as well as the cities which are railroad and financial centers, and, therefore, demand such protection. The long-range fire could only be properly resisted by vessels of equal strength with those of the enemy. Indeed, the monitors could be armored more heavily and armed with heavier guns than any probable adversary. Of considerably less draft than the armored sea-going ship, they could, by operating among the shoals, avoid ramming and even torpedoes.

To gain such advantages, speed must be sacrificed, but it is quite evident that, for the defense of harbors and bays, the advantages of extra thickness of armor and of superior power of gun more than compensate for that loss.

But the plan now being carried out does not stop at a system of defensive warfare. The ***Puritan*** is a type of the class of sea-going monitors and is now being completed. She will carry four 10-in. guns and have 50 in. of free-board. Her coaling capacity will be 400 tons, enough to steam with from New York to Panama and have sufficient left to manœver the vessel in a fight. She will be able to carry 100 rounds for each gun and will be supplied with torpedo nets and very heavy machine-gun batteries.

It is not generally considered possible to bar the progress of an armored fleet by the severe fire of the battery. It was necessary, therefore, that the monitors should have accessories, and it was to provide them that Congress appropriated $2,000,000, exclusive of the cost of armament. Each monitor will have as such accessories from 8 to 10 torpedo-boats, rams and sub-aqueous torpedo-boats.

The second feature of the accessory plan is the armored torpedo-boat, which may, perhaps, be better understood as a monitor without a turret, so built that it will deflect shots from the largest guns, make great speed, and, being fitted with rams, will also be capable of destroying the netting which surrounds armored vessels while it moves directly against the side of an enemy's vessel. These boats will also be so planned as to carry, if necessary, dynamite-guns throwing the aerial torpedo. In this way the armed torpedo-boat will be fitted to explode in every conceivable way the most destructive material known to modern warfare.

The third feature of the auxiliary plan is the employment of first-class torpedo boats in conjunction with the armored torpedo-boats, so that, while the latter may make it possible to reach the sides of the vessels of an attacking fleet, the swift torpedo-boats may take advantage of the work and surround the vessel attacked. Of this class, it is proposed to have from 4 to 6 for each monitor. In this way the floating battery of massive steel and iron will

be able to go out and meet the enemy, and, accompanied by a little fleet carrying the most destructive implements and material that invention has yet provided, give battle to the invading vessels so effectually as to make the safety of all of our great harbors and bays practically assured.

The Secretary of the Navy has approved the recommendation of the Board and accepted the proposition of the Pneumatic Gun Carriage & Power Company to furnish pneumatic carriages for the guns of one of the monitors, and also to furnish pneumatic apparatus for elevating and revolving the turrets, steering and ventilating the monitor *Terror*.

The advantages of the pneumatic system are set forth as follows, in a letter addressed to the Secretary of the Navy by the company:

"Compared with gun-carriages now worked by hand, and the few operated by steam and hydraulic power, the pneumatic system presents the distinct advantages herein set forth. In addition to the disadvantages of steam machinery for working guns, as stated by the Naval Board, the hydraulic recoil check must be employed therewith (as with the hand-worked carriages) with its uncertainty of pressures, and necessitating mechanical devices for holding the gun in battery, and also having no elastic cushion, subjecting the carriage to violent shocks on the return recoil in a sea-way, notwithstanding the buffers used to lessen the shock. In the system herewith described, the short recoil of naval guns is taken up by air at high-pressure in the recoil-cylinders, hereinafter described in detail; the compressed air for training and elevating the gun is carried at a constant pressure of 100 lbs. to the square inch, while that in the recoil-cylinders is held at a pressure of about 500 lbs., being supplied from an additional receiver below decks; when the gun recoils, the full effect of this elastic and increasing pressure is exerted in front of the pistons, until the counter-recoil begins, when the pressure is equalized automatically on both sides of the piston, and the gun returns to battery by its own weight without shock, and is held there by the pressure. In case of accident to the pneumatic supply, the traversing and elevating can be operated by hand, while any leakage from the recoil-cylinders is amply compensated for by the volume of air at atmospheric pressure pumped in by the cylinders themselves at each discharge of the gun. Furthermore, in the extreme case of unusual leakage and accident to the pumping engines, the recoil-cylinders can be charged from portable air flasks. The traversing, elevating and loading are accomplished by the means shown with great rapidity, giving a maximum of efficiency of the gun with a greatly reduced crew. The valve movement of the air engines for training and elevating permits of rapid motion in either direction, and of holding the gun fixed at any point. The elevating gear moves parallel with the recoil of the top carriage, and, the connection to the elevating band being elastic, the gear is not subject to injurious shocks. The loader (with sponge-head) can be attached to the rear of the carriage where deck space permits, or can be retained at any convenient point, and the carriage trained rapidly to it for loading. After receiving the shell or cartridge from a truck bearer, one movement of a lever elevates the loader to the proper angle and extends it into the gun-chamber; the reverse movement withdraws and levels it. The actuating machinery and connections are not exposed, but are located between the brackets underneath the gun—the extreme width of carriage and gears being much less than in the corresponding Government carriage. We have, by these means, utilized and practically applied to the working of guns of any size the evident advantages of compressed air, which can be easily carried at any desired pressure by use of the normal steam pressure in a vessel of war, and which is cool, clean, free from condensation or freezing, and, above all, furnishes an elastic cushion at any desired high-pressure for resisting the shock of recoil and counter-recoil without injuring the carriage."

STEEL GUN FORGINGS.

The Midvale Steel Works, of Philadelphia, were the only bidders for furnishing the 22 sets of steel forgings for the 6-in. breech-loading rifled guns, oil-treated and annealed, proposals for which were closed September 27. Two bids were submitted by this firm—one for supplying the forgings rough-bored and turned, oil-treated and annealed at $123,284; and the other for supplying the forgings, with tubes, jackets and trunnions, to be rough-bored and turned by the Navy Department, and the other work by the contractor, at $108,799. About 156 tons of forgings are involved in this contract. According to the terms of the contract to be entered into, the contractor must furnish one set of the forgings not later than December 31 next, and not less than one set every 15 days thereafter, the delivery to be completed within 15 months from the date of contract. The work of fabrication of the guns, for which these forgings are intended, will be performed at the Washington Ordnance Foundry. The guns are intended for the new vessels now building.

THE DYNAMITE GUN.

In addition to the public test of Lieutenant Zalinski's pneumatic dynamite gun, noted last month, some further tests were made early in October. These trials were intended to further determine the question of its accuracy of fire. Ten shots were fired, each projectile being loaded with 55 lbs. of sand, and weighing altogether 140 lbs. Firing commenced at 10.42 A. M. on this series and ended at 10.52.30, showing a rapidity of fire of about one shot a minute. The elevation throughout was 14°56'.

The next shot, at an elevation of 32°42', had a range of over 2½ miles, falling close to the shore of Norton's Point. In this case, the projectile was charged with 100 lbs. of sand (representing gelatine), the whole missile weighing 203 lbs. The time taken in the flight of this shot was 24⅗ seconds, the initial pressure of compressed air being 975 lbs. per square inch and the final pressure 525 lbs.

The experiments closed with two shots, with an elevation of 15°, using 100-lb. projectiles, weighing in all 203 lbs. each. The gun was sighted for 15 yards to the left, and the shots fell within 3 yards to the left. The first projectile was 10 seconds in flight; initial pressure, 750 lbs.; final pressure, 625 lbs. The second shot was 9.04 seconds in the air; initial pressure, 750 lbs.; final pressure, 615 lbs. Range, 1,772 yards.

The shots were fired from the experimental gun at Fort Lafayette in the midst of pouring rain.

Of the time shells fired, two fell short 50 and 70 yards. Six would have hit a target of the size of the *Silliman* (the vessel used as a target in the first trial), and two others would have exploded sufficiently near to have injured her seriously. This was the first time that rapid firing with a large number of shells was attempted, and the experience indicated a modification in the arrangements of connection between the storage reservoirs and the gun. This is easily remedied. Lieutenant Zalinski ascribes the short range of two of the shells to this cause. He thinks, with the changes to be made, he could improve the record made, excellent as it seems to us, and as it appeared to impress the foreign officers who witnessed the experiments. Lieutenant Zalinski thinks that the dynamite cruiser guns can be fired at the rate of twice a minute. The contract calls for a rapidity of fire of once in two minutes.

At a distance of about 1,800 yards from the old fort, a small boat was made fast to a buoy, the two combined serving as a target.

A Sham Torpedo Battle.

(From the New York *Herald*.)

THE torpedo attack on the cruiser *Atlanta*, which took place in the harbor at Newport, R. I., on the evening of October 11, resulted in a victory for the defense, the *Atlanta*. So judged the umpires when the fight was finished, and so said all who were in a position to gauge fairly the friendly battle.

Thus has been given another partial solution of the naval war problem which has for its factors the ship and the torpedo. Neither abroad nor at home has this great tactical question been settled. After all, the one vigorous disagreement between the opinions of naval experts

is whether in high-sea duels and in fleet engagements the torpedo is or is not to replace armored battle ships and their unarmored auxiliaries.

The cruiser *Atlanta* as the target, and the torpedo flotilla of the other vessels of the squadron as the missiles, have now added another interesting chapter to the discussion.

It was a game of strategy and tactics deftly conceived and intelligently played, and was throughout a credit equally to the victor and the vanquished. It was an interesting contest, this object lesson on the science and art of naval warfare, though the pity of it all is that the material resources of the attack were so unworthy of the intelligence forced to use them.

On the one hand was a modern cruiser, defended, to a great degree, by means improvised from equipments designed for far different purposes; on the other was a little squadron of steam launches and pulling cutters, whaleboats and gigs, which were slow in speed, noisy in action, hampered by adverse tides and strong breezes, and so weak in defense that they were compelled to attack with the same offensive powers that Cushing, years ago, employed to destroy the *Albemarle*.

Broadly generalized, it was not so much one of those lessons which teach what attack and defense are as a proof of the possibilities inherent in a cruiser of modern design to utilize for her safety the appliances which have been more or less niggardly furnished her.

From the very beginning it was apparent to every sea-officer that the defense must be successful, though this in no way lessened the ability, energy and zeal shown by Captain Bunce of the *Atlanta* and his officers and crew. The lesson was a useful one to many who assisted the most important, perhaps, of all those practical experiments where, through a realization of the difficulties, our officers are being enabled to determine how much behind the age the navy has lagged in the keen race, not for supremacy but for equality with the great marine Powers.

The problem offered for solution was this, and it is an old one measured by the progress of naval science: An enemy's vessel is supposed to be anchored in a closed harbor, with no means of defense except such as are offered by the equipment of the ship; seaward there is a blockade, against which there is faint hope of escape by sudden dash, while landward an enemy's occupation of the strategic points offers no chance as assistance. These known quantities are complicated by the imminent danger of assault from torpedo-boats, from the possible presence of submarine mines and the certainty that any victory is but a temporary one.

Of course this problem has been attacked before—notably by the French and English in their manœuvres of the past two years; but with them the conditions were different, since the attack was supposed to be equal to the defense.

Torpedo enthusiasts, even on the face of latter-day results, are not yet satisfied that Gabriel Charmer was not right when he declared that "a squadron attacked by night torpedo-boats is a squadron lost."

Admiral Luce, in pursuance of the plan he has formulated for the drills of the North Atlantic squadron, took measures for making this attack as nearly practical as possible. The general theme was submitted to the 21 officers now in attendance at the War College, with a request that they should prescribe such rules as seemed best fitted to the circumstances. These officers in turn appointed a sub-committee, and, after careful examination and discussion, the following regulations were adopted:

THE REGULATIONS OF THE FIGHT.

1. To judge of the events connected with this attack several umpires will be stationed on board the *Atlanta*, and one umpire will be appointed to each torpedo-boat and each guard-boat.

2. Umpires are to consider themselves as such, not only for their own special posts, but for any operations of attack or defense which may come under their observation.

3. Any torpedo-boat shall be judged out of action:

(*a*) When under the fire of heavy guns a sufficient time to receive three rounds therefrom—say one minute.

(*b*) Or is under fire from rapid-fire guns a sufficient time to receive fifteen rounds therefrom—say three-quarters of a minute.

(*c*) Or is under Gatling-gun fire within 500 yards for one and a half minutes.

(*d*) Or is under a small-arm fire (of not less than ten pieces) within 500 yards, for one and a half minutes.

(*e*) Or is under an effective fire during 15 seconds while within the beams of the search light.

(*f*) Or receives water from the ship's hose during one-quarter of a minute.

(*g*) Or shall be within the effective range of a defense torpedo or mine at the time of the explosion of the same by the defense.

4. Any torpedo-boat succeeding in attaching an explosive charge to any part of the defense will make her claim by making her number three times by blasts from her whistle and shall be free to retire.

5. Any torpedo-boat which, without being discovered or ruled out, shall approach the *Atlanta* to within 20 ft., shall be considered as having successfully torpedoed her and will make her claim by firing a green "Very's signal light" into the air and shall be free to retire.

6. Guard-boats which shall fail to discover the approach of a torpedo-boat until the same is within 20 ft. from them shall be considered as destroyed.

7. When a torpedo-boat is put out of action from the *Atlanta*, the fact will be signified to it by hailing it or by "Very's signal light" discharged in the direction of the boat if not within hail. The boat judged out of action and notified of the fact shall immediately acknowledge it by reporting her number if within hail; otherwise by making her number once by whistle.

8. The decision of an umpire shall be final.

9. If the *Atlanta* is torpedoed once she shall be considered as disabled, and if torpedoed twice as destroyed.

10. The termination of the attack will be signified by the recall sounded by bugle from the *Atlanta*.

11. These rules shall, after approval by the committee on the same, be immediately communicated to all parties concerned therein.

This programme was submitted to Captain Bunce of the *Atlanta*, representing the defense, and to Commander C. M. Chester of the *Galena*, to whom was intrusted the attack, with instructions to adopt such measures as would enable them, while complying with their letter and spirit, to utilize the appliances at their disposal for the special duties each had to perform. Both officers were left untrammelled by any official interference, and in the end Commander Chester adopted the following plan for his offensive operations:

THE ORDERS FOR THE ATTACK.

The torpedo attack will take place on the night to be designated.

The attacking force will consist of six steam launches and four pulling boats (gigs or other light boats), all to be under the command of Commander C. M. Chester.

The steam launches will be numbered successively from one to six inclusive, and the pulling torpedo-boats as per following list annexed.

All torpedo-boats will be armed with one light torpedo spar, fitted with a primer that will explode if closing nearer than 20 ft. to the attack. They will also carry two or three Very's (red) signals to be fired only when assistance is needed. The eight pulling or decoy boats will be armed with hand torpedoes, to be attached to the obstruction around the *Atlanta*.

The object desired is to have the defense contemplating an attack only by steam launches, and then suddenly find itself required to throw the electric light over a large number of boats, with the possible result of permitting one or more of them to take advantage of the dark rays and make a successful attack.

Just as soon as it gets dark—before 7.30 P. M., if possible—the four boats of the *Richmond* will proceed to the west end of Rose Island and endeavor to keep in ambush until the commencement of the attack. The four boats of the *Dolphin* will proceed at the same time around the north end of Goat Island and lie in ambush near the south end of that island. The boats from the *Galena* will, by a détour, endeavor to reach the cover of the wharf at Fort Adams. The *Ossipee's* boats will remain under cover of that ship.

At 8.15 P. M., the boats from the several divisions will deploy to a distance of about 200 yards, the steam launches leading, followed by the decoy boats, and the pulling torpedo-boats last. The advance will commence at the same time or

immediately after the deploy, when each boat will endeavor to reach the *Atlanta* as soon as possible. Of course, it should be the aim to take advantage of the dark sector of the *Atlanta's* electric light to secure a score within 30 ft. of that ship. The decoy boats will strive to reach the obstructions around the vessels should their consorts be counted out.

The *Ossipee's* division will delay its advance slightly to allow the other divisions to get their distance.

When the recall is sounded the steam launches will assemble alongside the *Atlanta* and all other boats will return to their respective ships without further instructions, the pulling torpedo-boats delaying long enough to land their umpires on board the *Atlanta*.

Should the umpire (one in each boat) declare a steamer within the proper distance to score a point, she will make her number three times and withdraw. If discovered, and it is so indicated by proper signal from the *Atlanta*, she will make her number once and withdraw. Short toots corresponding to the numbers given in this order will designate the steamers. The other torpedo-boats will, in like manner, give their number and the name of the ship to which they belong once or three times and withdraw. Watches will be set at sundown, which is 5h. 12m.

The boats will have their numbers tacked on the bow.

Organization—No. 1, steam launch *Vixen*, Commander Chester; No. 2, steam launch *Richmond*, Lieutenant Nazro; No. 3, steam launch *Ossipee*, Lieutenant Delano; No. 4, steam launch *Galena*, Lieutenant Sharrer; No. 5, steam launch *Dolphin* (No. 1), Lieutenant Marshall; No. 6, steam launch *Dolphin* (No. 2), Lieutenant Cutler.

No. 1, *Richmond's* cutter (torpedo-boat), Lieutenant Kilburn. No. 2, *Richmond's* whale-boat, Cadet McMiller. No. 3, *Richmond's* gig, Cadet Russell.

No. 1, *Ossipee's* cutter (torpedo-boat), Ensign Snowden. No. 2, *Ossipee's* whale-boat, Ensign Brainerd. No. 3. *Ossipee's* gig, Naval Cadet Brown.

No. 1, *Galena's* cutter (torpedo-boat), Ensign Gibson. No. 2, *Galena's* whale-boat, Naval Cadet Young. No. 3, *Galena's* gig, Naval Cadet Bristol.

No. 1. *Dolphin's* cutter (torpedo-boat). No. 2, *Dolphin's* whale-boat.

Preparations were commenced upon the *Atlanta* at 3 P. M. on Monday, and by sundown the trim-looking cruiser was in a fighting form which recalled forcibly the appearance of the more splendid English war machines, as they steamed into position for the bombardment of Alexandria. Everything aloft except the lower yards was sent down, the rigging and gear being neatly and securely lashed, and the lower mast heads, especially at nightfall, looking not unlike vigilant sentries, silhouetted against the sky and eager for any enemy that might appear.

A stout 5-in. steel hawser was passed around the ship just high enough above water to prevent a hostile boat going over or under it; this was guyed clear of the ship by the unrigged spars, the topsail yards being used to starboard and the topmasts to port. These were supported by pennant tackles from the lower yardarms while the bights of the hawser were secured to their outer ends by stout lashings.

Forward, two spare booms were rigged 24 ft. outward, and to these were attached a secondary steel hawser that encircled the ship from stem to stern. Upon the main hawser, at distances 30 ft. apart, were suspended 20 torpedoes, each controlled electrically, and so arranged as to fire on a closed circuit by contact, and with such a radius of fire that any boat striking the hawser within a space of 15 ft. was exposed to the destructive action of one or two torpedoes.

Towing astern was a whale-boat which supported a steam pump hose in such a position that a vigorous stream of supposititious hot water could be directed against any approaching boat, while forward, another arrangement of the same hose enabled this method of defense to be usefully employed.

Fifty yards astern of the ship, a hawser, carrying spare booms and buoyed by empty water casks, was anchored, and from this was suspended ropes which were intended to entangle the screws of the attacking steam launches.

Two search-lights, which subsequently did most effective service, were mounted, one aft on the starboard and one forward on the port side, and their 24-in. lenses were so arranged that the 16,000 candle power developed was directed without dispersion, in a cylindrical tube of light, close to the water and with a range of over 1,500 yards.

The broadside defense being nearly perfect, the shifting 6-in. guns were trained so as to fire fore and aft, thus enabling five guns to be brought on these bearings, while there was always a beam fire of at least eight pieces.

It will be seen from this that the defense consisted of two principal lines—an outer one, composed of search-lights, battery and guard boats, and an inner one of hawsers, spars, booms and torpedoes.

Contrary to general expectation, but as it proved with great good judgment, Captain Bunce moved his vessel and took up a new anchorage further seaward in the outer harbor.

Up to this time the squadron, consisting of the flagship *Richmond*, the sloops of war *Atlanta*, *Galena* and *Ossipee* and the dispatch boat *Dolphin*, had been disposed in a column two cables apart heading N. N. E. and S. S. W., the flagship furthest to the northward, and the *Atlanta* at the southerly end of the line.

In this position certain effective defenses of the *Atlanta* were neutralized, while her rear was exposed to attack in the most vital part, but in the new place chosen to receive the enemy, a large section of offence was cut off by the interposition of Rose Island, which bore about northeast, distant about 1,000 yards.

The day had opened with a strong gale from the southward and moderately rough water, but as the morning grew the wind and sea subsided, though the sky was still overcast and lowering. As the sun went down the wind freshened, and the ebb tide was running so strongly as to promise that the attacking flotilla would have a severe task in taking up favorable positions.

At 7 o'clock, the *Atlanta's* crew went quietly to quarters, all lights save the electric battle lanterns were extinguished, and with unremitting search the long cylindrical beams of light swept the encircling waters and the land. Soon after 7, the umpire selected for the ship reported on board, and then from every coign of vantage eager eyes peered into the gloom for the first approach of the enemy.

It was a weird and striking scene—the dismantled ship, the silence broken only now and then by quiet words of command, the stalwart bluejackets each in his place, the long line of bright lights showing at the rim of the town and fading into the slight rise where Miantinomi Hill crowns the city, the muffled pulsations of the steam pumps below, and outward the subdued rush of the busy guardboat crossing and recrossing within the boom on the line of attack astern. Everywhere there was an alertness, a zeal, which spoke volumes of praise for what these trained seamen would do in time of actual war.

There was a quick cry of recognition about 7.30 o'clock as the starboard search light caught in its mesh of illumination the first of the approaching boats, and then when the agreed time had elapsed there was the snappy report of a fiery signal, and then an answering light from the disabled boat—disabled by force of agreement. From this time forward it was one succession of discoveries—boats to starboard, boats to port, boats astern and boats ahead. Nothing escaped those pitiless lights, and with the colored flaring of the bursting signals there came at intervals, when the discovery was made close aboard, the sharp rattle of the Gatling-gun cranks, the snap of the sharpshooters' rifles on the quarter deck and superstructure and the brief decision of the umpire:

"Steam launch *Vixen* disabled."

"*Ossipee's* whaleboat out of action."

"*Galena's* gig"—and very close did this one and the *Dolphin's* steam launch come—"*Galena's* gig and *Dolphin's* launch disposed of."

There is not much more to tell, except to say that of all the flotilla not one was enabled to get within any destructive distance of the *Atlanta*—indeed, so complete was the work of defense that the much prized hose with its supposititious aqueduct of boiling water was never called into play. The recall was sounded at 9 o'clock; the steam launches came alongside; the pulling boats disembarked their umpires, and from each and every officer came the story:

"It was of no use; we were discovered before we got within fair fighting distance, and by the rules we are fairly whipped."

Aluminum Bronze for Heavy Guns.

MR. ALFRED H. COWLES read a paper on the subject expressed in the above title before the United States Naval Institute at the meeting held in Annapolis, October 27. Advance copies were issued and sent to a large number of metallurgists and ordnance officers, who were invited to discuss the question.

A brief abstract of the claims made in Mr. Cowles's long and interesting paper is as follows:

The question for discussion embodied in the paper is: "How near can aluminum bronze approach the requirements of a perfect gun-metal?"

Assuming that the gun-carriage takes up the recoil, a perfect gun might be described as a gun of minimum weight and simplest construction, which shall be able to resist a maximum internal pressure without permanent distortion, and thereby be enabled to throw a projectile with maximum energy. It is impossible to attain perfection. For safety, the metal in a gun should have the property of stretching much beyond its elasticity; thereby danger of violent explosion is greatly diminished. In order to make the nearest approach to the above, the metal employed should have as high tensile strength, and elastic limit, and as great elastic extension as possible. Its ductility should be great, if it can be obtained without sacrificing its other properties. Hardness to resist erosion is not a principal requirement, as it is now a common practice to protect the inner wall of a gun with a steel tube which can easily be removed. Further, and of greatest importance, the metal should be of such a nature as to enable us to make the whole gun in one solid piece, and yet attain, as near as possible, a finished gun, in which the initial tensions of the metal shall vary from the bore outwards to correspond exactly with the variation in strain thrown upon its different parts at the moment of explosion.

The Rodman cast-iron guns approach these requirements, inasmuch as they are solid throughout; and it is to be noted that, although steel in the modern built-up steel guns has three times the tensile strength of cast-iron, yet the powder pressures that are obtained in service show that not more than 25 per cent. increase in efficiency is gained in the built-up steel gun over the rifled cast-iron guns, and the latter are more enduring.

Recent experiments have developed the fact that there are numerous alloys of aluminum with copper, with copper and nickel, and with copper and zinc, castings of which equal steel forgings in their physical properties. With these alloys at command, which can be cast more readily than cast-iron, there are two well-tried methods of fabrication that can be employed to give solid guns of much greater destructive power than can possibly be obtained with steel.

First the Rodman: Were this employed, aluminum bronze of more than three times the tensile strength of cast-iron could be used. The temperature at which this grade of bronze solidifies is 1,600° Fahrenheit, as compared to 2,700°, the melting temperature of cast-iron. With this low temperature, we could heat the outside of the mold as hot as the molten metal, and thereby cause all cooling to take place entirely from within. This would be the ideal perfection of the Rodman method of casting guns.

Second, and probably the best method to follow, is the Dean process. In this case the gun would be cast in an iron mold of a grade of aluminum bronze, castings of which have a higher tensile strength and ductility than the finest quality of mild-steel forgings. The solid gun would then be bored, and conical chilled-steel mandrils of gradually increasing diameter successively driven through the bore. The metal around the bore, by this process of cold stretching, would, thereby, be given a greater strength and hardness, a higher elastic limit and greater elastic extension. These properties would gradually vary till the outer circumference of the gun is reached, where the metal is left in its normal condition of great toughness. It would be impossible to burst such a gun with four times the powder pressure now used in the built-up steel gun. The wall would be solid. There would be no danger of crystallization. The finished gun would have the color and the luster of gold. It would not be corroded by salt water. Plants for producing aluminum bronze and casting such guns would not require more than one-third as great an outlay in capital as it is proposed to invest in plants for the construction of built-up steel guns, and not one-quarter the time would be necessary to build either the aluminum plant or guns. The mineral resources of our country are capable of supplying inexhaustible quantities of the raw material necessary for the production of aluminum alloys. Were our Government at the present time enabled to make the great advance proposed above in the art of gun fabrication, we would render valueless against us the present armaments of Europe. Cast guns can be made from aluminum bronze, at its present cheapened price, at 20 per cent. less cost than forged guns of steel; and further, 60 per cent. of this cost is capital stored away in the metal of the gun, which can be remelted and used over an indefinite number of times. This is not the case with steel guns, which, when once destroyed, are a total loss, 98 per cent. of their cost being in their fabrication.

A YEAR'S WORK OF THE SIGNAL SERVICE.

GENERAL A. W. GREELY, Chief Signal Officer of the United States Army, has submitted to the Secretary of War his annual report upon the operations of the Signal Corps. The report begins by inviting attention to the condition of the military signaling system, and says that for several years there was not even a division of military signaling in the office of the Chief Signal Officer, and it is only within the past 18 months that the slight and perfunctory attention paid to this branch of the service has been rectified.

Despite the advisability of experiments and improvements for such active service, the Chief Signal Officer regrets to say that the field-telegraph train of the Signal Corps is practically the same now as that used nearly a quarter of a century since.

The system of visual signaling also remains the same, with reference to flags and torches, as in war time. Efforts are being made, with gradual success, to simplify the models of the old and cumbersome flag kits and to replace the torches by a more satisfactory and economical element.

It is intended to make careful experiments during the coming year with homing pigeons, and the Chief Signal Officer has directed that experiments be made from Key West toward Cuba, with the expectation, based upon the opinion of experts, that, by training these birds in flights from seaward, a United States squadron in the vicinity of Havana might be enabled to communicate rapidly and certainly with the naval station at Key West. If such flight be possible from Cuba, it could be eventually extended to the Windward Islands, even to Nassau.

Reference is made to the good results attending the use of expert signalmen in General Miles's campaign, and the case is used as an illustration of the necessity for special training and drill to procure officers and men whose services can be relied upon in the field. It is said to be evident from the record of this and past years that, instead of the Army being properly and efficiently drilled in military signaling, there is not an average officer to a regiment who is competent to transmit signals—by sun, flag and torch—day and night, except those who have passed through a regular course of instruction in direct connection with this office.

Touching weather forecasts, General Greely says he has been strongly urged to furnish special predictions for cities, towns and corporations—a work which, so far, this office is unable to satisfactorily undertake, owing to the limited time which elapses between the receipt of the

telegraphic reports and the hour at which the predictions must be issued to the general public. He hopes, however, during the ensuing year, to make arrangements which, in addition to providing the Northwest with more accurate warnings of coming cold waves, will also furnish the great centers of population with special predictions.

The increase in the length of hours in the tri-daily indications has, it is said, naturally resulted in a reduced percentage of verification, the diminution amounting to 7 per cent.; but it is believed that this may be compensated for by increased skill and practice. On this point the report says:

It has been a subject of complaint that the indications of this service have not improved to the extent expected, and since the statement has been officially put forth that the indications are made by the same officers who have made them for years, it is presumed that the public labors under the same misapprehension.

Such is not the fact, as within the past three or four years the relief of the old officers detailed from the line of the Army has been forced upon the Chief Signal Officer by Legislative action. In consequence, it followed that the young officers of the Signal Corps, who have only within the past year or two received any extended instruction in meteorology, have been assigned to this important duty. Within the past year, three officers have necessarily been assigned to indications work who never before have performed duty of this character.

It consequently followed that, through restrictive legislation, the Chief Signal Officer finds himself compelled to permit the new officers to serve their apprenticeship in predicting at the expense of the whole country. It has occurred, as might be expected, that the novices in the work at times made errors that subjected the service to criticism, which, well merited in such cases, cannot be considered valid criticism of the methods followed by the service.

The general percentage of successful indications during the year has been: For weather, 74.5; wind, 69.1; temperature, 74.4; a general average of 73.9. This result is not satisfactory to the Chief Signal Officer, but the reasons for it have been stated as above.

Reference is made to the discontinuance of the West Indian service, and its renewal is suggested, in order that notice may be given of approaching hurricanes.

During the current year there have been 1,510 storm signals of all kinds ordered, of which 1,034, or 68.5 per cent. have been verified. This percentage is the lowest for years, and the causes therefor are those set forth in treating the subject of indications of this service.

The Bureau has in view the early display of signals which will not only indicate whether the storm is to be light or severe, but also show whether winds are to come from a special quarter, and—a matter at times of great importance—whether the storm center is approaching or has passed the station.

In order to meet the needs of the Northwest and to comply with the earnest applications from citizens and corporate bodies of great vested values the Chief Signal Officer has under consideration the plan of stationing an indication officer at St. Paul, Minn. This arrangement would enable that officer to receive his reports upon an average of an hour earlier than in Washington, and would further enable him to send out warnings of cold waves in that section from two to five hours earlier than is now done. Of the cold-wave signals sent out, 78.06 per cent. were verified.

The Chief Signal Officer has faithfully carried out the arrangements authorized by the Secretary of War, which assured Professor Mascart, Director of the Central Meteorological Office of Paris, that France and England should have the hearty co-operation of the United States Signal Service in the transmission of such weather despatches as would benefit the meteorological service of those countries. This information has so far been collected and telegraphed at the expense of the English and French governments, but, in view of the hearty and generous co-operations which these nations have always extended in any scientific matters of interest or value to the United States, it is recommended that the attention of Congress be called to the propriety of making an appropriation for this service, which would scarcely amount to $1,000 a year.

Touching the river and flood reports, General Greely says it seems to him that such a system of river and rainfall stations might be established as would enable a practised indication officer to predict, with considerable certainty, the extent and continuance of any great flood, many days in advance, so that timely warnings would afford ample opportunity for such precautions as would mitigate the severity of such disasters.

The report mentions that the general bibliography of meteorology is nearly completed, the subject classification and author indexing having been finished during the year, in addition to the revision of the material on hand and the collection of the new titles.

The recommendation for the purchase of a suitable building in Washington for the use of the bureau is renewed, and it is shown that the result would be economy in the saving of rental.

ESTIMATES.

The estimates of the service for the fiscal year ending June 30, 1889, are $80,155 less than those for the current fiscal year. The re-arrangement of the work of the service, the discontinuance of certain sections of telegraph lines, an improved weather code and other changes in the direction of simplicity and economy have enabled this considerable reduction. The decreases will, it is said, in no way affect the efficiency of the present service.

General Greely concludes his report with a plea for a regular organization of the corps, pointing out the faults of the existing service and suggesting an organization comprising, besides the Chief Signal Officer, one major, six captains, six first lieutenants, two professors and two junior professors. A detail of six lieutenants selected from officers who have served two years in the line of the Army would insure material from which the corps could be properly recruited by future competitive examinations. The proposed organization would leave the regular corps with fourteen officers, against sixteen at present, and at practically the same expense. No officer should be promoted in this corps without examination under rules similar to those in force in the Medical and Ordnance Services. Regarding the enlisted men in Washington, he believes that the interests of the government, both in efficiency and economy, would best be subserved by the discharge from the Army of the purely clerical force in the City of Washington, and the organization of a civilian clerical force, such as now obtains in the offices of the Adjutant General, Surgeon General, Quartermaster General and elsewhere.

Steel Lace.

THE Pittsburgh *Chronicle-Telegraph* says: "The question of making laces of iron and steel for ladies' and children's wear is again being discussed in art, mill and fashion circles. At the Centennial, in 1876, a piece of steel rolled by a Pittsburgh mill was on exhibition which was so thin and light that it weighed much less than a book leaf, and could be blown from the hand easier than a piece of paper of the same size. The iron leaf was rolled on a train of rolls upon which heavy tank and boiler iron is now rolled.

"Experts say that curtains and other fine laces can be made of soft malleable iron, and in every way be used with greater satisfaction than cotton laces. The sheets will necessarily have to be rolled down to an exceedingly low gauge and then pressed into any desirable pattern and shape. There will be no trouble in furnishing iron laces for ladies' and children's wear, with their names and other ornamentations in filigree design. An introduction of steel lace would establish in Pittsburgh an industry that would give work to, at least, 3,000 men and consume annually not less than 76,000 tons of steel, which is now a drug in the market at less than 2 cents a pound. Steel lace, unlike cotton, can be made light or heavy without affecting the grade, color or brightness. We may yet see fashionable ladies wearing steel shawls and trimmings for their hats and dresses."

MESSRS. BOWLER & Co., Cleveland, O., manufacturers of car-wheels, have just completed a new foundry. The building is a substantial structure, 140 ft. wide and 200 ft. long, containing 16 cranes and molding floors, and each floor holding 20 wheels.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

CHAPTER I.

FORCE AND MOTION.

Question 1. *How do we get our first notion of the nature or of the effect of force?*

Answer. It is suggested to us by the so-called muscular sense; that is, we have a peculiar feeling of pressure when we try to move any object or piece of matter.

Question 2. *What is "force?"*

Answer. We know nothing about the absolute nature of force. All that we know is what we can learn through the senses of its effects. It has been defined as "that which *affects* the motion of matter;" and again as "any action between two bodies which changes, or tends to change, their relative condition as to rest or motion." In the plainer words of a distinguished author* "the word force is obviously to be applied to any pull, push, pressure, tension, attraction or repulsion, etc., whether applied by a stick or a string, a chain or a girder, or by means of an invisible medium" such as the attraction of gravitation or electricity."

Question 3. *How is the motion of one body in relation to others produced?*

Answer. It is produced by the exertion on it of force.

Question 4. *Are bodies ever made to move in any other way excepting by the action of some force or forces on them?*

Answer. No. Part of what is called the first law of motion is that "*a body at rest remains at rest until some force acts upon it to set it in motion.*"

Question 5. *What is the other portion of the first law of motion?*"

Answer. "*That a body in motion continues with its motion unchanged, either in direction or velocity, until acted upon by some external force.*" Thus a top can be made to spin in the open air for a minute or more, but in a vacuum it will spin a much longer time, because there it has not the resistance of the atmosphere to overcome. If it be accurately balanced and revolves on a small steel point which bears on a glass plate, it can be made to spin in a vacuum for an hour or longer, because there the resistance, or force, which is opposed to its revolution is reduced to the lowest possible amount. Nevertheless, this force, however small, will check the speed of the revolutions of the top, and finally it will cease to spin altogether. As there is always some force which resists motion, there is a corresponding tendency which causes bodies about us, as we know them, to come to a state of rest.

Question 6. *When is motion said to be uniform?*

Answer. When a body passes over equal spaces in equal periods of time. Thus, the motion of the minute hand of a clock is uniform, because it passes over equal spaces on the clock face in each minute or hour. A railroad train is said to have a uniform velocity when it runs successive miles in the same number of minutes or seconds.

Question 7. *What is meant by accelerated and retarded motion?*

Answer. Motion is *accelerated* when the spaces passed over in equal periods of time become greater and greater, and motion is *retarded* when these spaces become smaller and smaller. Thus, if a railroad train should run one mile in five minutes, the next one in four, and the following ones in three and two minutes each, its motion would be said to be *accelerated.* A stone falling from any height is another example of accelerated motion. On the other hand, a railroad train, when it is being stopped, and a stone thrown upward are examples of retarded motion.

Question 8. *What is meant by uniformly accelerated or uniformly retarded motion?*

Answer. Motion is said to be uniformly accelerated or retarded when the increase or diminution of velocity in each interval of time is the same. Thus, if a railroad train should have a velocity of two-tenths of a mile at the end of the first minute, three tenths at the end of the second, four-tenths at the end of the third and five-tenths at the end of the fourth, its moti n would be said to be uniformly accelerated. A falling body is another example. Its velocity is 32.2 feet per second at the end of the first second, 64.4 at the end of the second, 96.6 at the end of the third, etc. In the case of the railroad train, the velocity is increased one-tenth of a mile for each minute, and that of the falling body is increased 32.2 feet for each second.

* P. G. Tait. "Recent Advances in Physical Science," p. 35.

Question 9. *How is the velocity of a moving body increased or diminished?*

Answer. By the action of force on it. If this force is exerted in the direction of the movement of the body, its velocity will be increased so long as the force, or the *motive power* as many call it, is greater than the resistance opposed to it. Whenever the motive power equals the resistance, then the moving body will have a uniform speed; and when the resistance becomes greater than the moving form, the velocity will be retarded.

Question 10. *How is this illustrated in a railroad train and a locomotive?*

Answer. When the locomotive starts, the speed of the train is increased, until its resistance is equal to the force or power exerted by the engine. If the train reaches a grade, and its resistance is consequently increased, its speed will be retarded. On a level, the speed will also be retarded if steam is shut off, either partially or wholly, so as to diminish the force or power which the engine exerts.

Question 11. *What relation is there between the force exerted on a moving object and its velocity?*

Answer. With any object of a given weight, the greater the force exerted the quicker will the speed be increased or diminished. Every boy has learned this in drawing a wagon or sled or in trying to stop one in motion.

Question 12. *Do we know how much the velocity of a moving body will be increased or diminished by a known force?*

Answer. Yes, this has been ascertained by the effect of the attraction of gravitation, which causes all objects to fall toward the center of the earth if their movement is not resisted by some greater force.

Question 13. *What is the rate of acceleration of falling bodies?*

Answer. It has been found by the most exact experiments, that at the surface of the earth all bodies falling in a vacuum, where the air offers no resistance, acquire a velocity of 32.2 feet per second at the end of the first second, 64.4 feet at the end of the second second and 96.6 feet at the end of the third, and so on with an increase of 32.2 feet for each successive second.

Question 14. *Can this increase in motion be represented in any way by a drawing?*

Answer. Yes, we can draw a diagram which will show to the eye the rate at which a body falls. To do this let us suppose that a stone is allowed to fall from 0, fig. 1, and that the distance 0 1 is drawn to any convenient scale to represent the distance, 16.1 feet, that it will fall in the first second; 1 2 the distance, 48.3 feet, that it will fall the second second; and 2 3, 3 4, 4 5 and 5 6 the distances it will fall in successive seconds. If now from 1 a horizontal line, 1 1', be drawn whose length

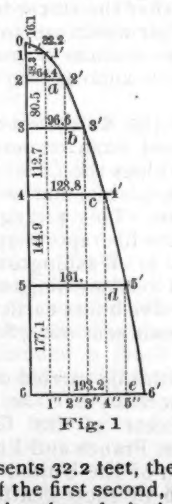


Fig. 1

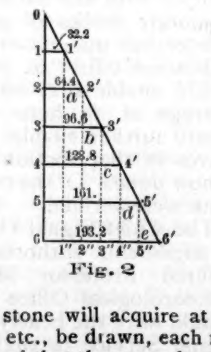


Fig. 2

represents 32.2 feet, the velocity the stone will acquire at the end of the first second, and 2 2', 3 3', etc., be drawn, each representing the velocity in feet per second that the stone has acquired at the end of the successive seconds, and a curve, 0 1' 2' 3' 4' 5' 6', be drawn through the extremities of the horizontal lines, then the horizontal distance of the curve from any point in the vertical line *o 6* will represent the velocity of the stone at that point.

Question 15. *In what way may this diagram be modified?*

Answer. For some purposes, which will be explained in a future chapter, it is more convenient to make the spans 0 1, 1 2, 2 3, etc., between the horizontal lines, which represent seconds, equal to each other as in fig. 2. The lines 1 1', 2 2',

etc., can then be drawn as in the preceding diagram, and the line o 1' 2' 3', passing through their extremities, will then be a straight line if the fall of the stone is uniformly accelerated, as it would be if it fell in a vacuum.

QUESTION 16. *How is the law which governs the velocity of falling bodies still further illustrated by the diagrams?*

Answer. Before this question is answered it will again be explained, and should be clearly understood by the reader, that in fig. 1 the spaces between the horizontal lines represent the *distances* through which the stone falls in successive seconds, whereas, in fig. 2 the spaces represent the *periods of time* or *seconds* occupied by the fall.

In both figures, the lines 1 1' represent the velocity, 32.2 feet per second, that the stone has acquired at the end of the first second. If its fall was not still further accelerated than the dotted line, 1' 1'' would represent its velocity. But in falling from 1 to 2 it again acquires an addition of 32.2 feet per second,—represented by the line *a 2'*—to its velocity, so that at the end of the second second it is 64.4 feet. By examining the diagram, it will be seen that during each second of the fall the velocity previously acquired by the stone is increased by the amounts represented by the lines *b 3'*, *c 4'*, *d 5'* and *e 6'*, each equal to 32.2 feet.

QUESTION 17. *How is the law which governs the distance through which a body will fall illustrated by the diagram?*

Answer. As shown in fig. 2 the stone starts from a state of rest at *o*, and at the end of the first second has acquired a velocity of 32.2 feet per second. Its average velocity during the first second is, therefore, one-half of 32.2 feet, so that it falls 16.1 feet in that time. As it has acquired a velocity of 32.2 feet at the end of the first second, it would fall that distance during the second second, but during that time it acquires an additional velocity of 32.2 feet which will cause its fall 16.1 feet further than it would if it was not accelerated during that period. The distance that it will fall in the second second is therefore $32.2 + \frac{32.2}{2} = 48.3$ feet. From the diagrams it will be seen that in each successive second the distance that the stone falls is 16.1 feet more than that through which it fell the preceding second.

QUESTION 18. *How can the velocity of a falling body be calculated?**

Answer. As shown by the diagrams the velocity which a stone acquires is equal to 32.2 feet per second at the end of the first second; at the end of the second second it is twice 32.2; at the end of the third second it is three times, and so on; so that if we *multiply 32.2 by the number of seconds that the body has fallen will give its velocity.*

QUESTION 19. *How is the distance through which a body will fall in a given time calculated?*

Answer. Multiply the square of the number of seconds, that the body has fallen, by 16.1. The product will be the distance fallen.

QUESTION 20. *Do all bodies fall at the same velocity?*

Answer. In a vacuum, where the atmosphere offers no resistance, they all fall at the same velocity. A feather will fall as fast as a piece of lead, and a cannon ball, weighing one pound, will fall as quickly as one weighing a hundred.

QUESTION 21. *What relation is there between the weight and the motion of a body?*

Answer. The heavier a body is, the greater will be the force required to move it and to accelerate or retard its motion. This we all learn by ordinary experience, as in drawing a wagon or moving a piece of furniture. We are apt to attribute it to the fact that the friction of heavy objects when rolling or sliding is greater than light ones, which is part of the reason why more force is required to move them; but if we suspend two cannon balls, one weighing one pound and the other a hundred pounds, by long cords, so that they can swing freely like a pendulum, with little or no friction, we will find that it takes a much greater force to move the heavy ball than is needed to move the light one the same distance in the same time. In this case there is hardly any resistance excepting *inertia*, which opposes the swinging of the balls.

QUESTION 22. *What is meant by inertia?*

Answer. It is defined as "that property of matter by which it tends when at rest to remain so, and when in motion to continue in motion."

QUESTION 23. *What relation is there between the weight and the inertia of a body?*

Answer. They are proportional to each other. That is, a body weighing a hundred pounds has twice as much inertia as one weighing fifty. It will be found that the heavy suspended cannon ball will take a hundred times as much force to cause it to swing a given distance in a given time as is needed for the light one. It is assumed that they are suspended by very long cords so that the arc or path in which they swing does not differ appreciably from a straight line.

QUESTION 24. *If this is the case why is it that a heavy object will fall as quickly as a light one?*

Answer. It is because its *weight*, which is the force that causes the heavy body to fall, is proportional to its inertia That is, each pound of inertia—if we may so express it—has one pound of weight or force to impel the body downward.

QUESTION 25. *Would a force acting upward, horizontally or in any other direction have the same effect?*

Answer. Yes, if it acted against a body which could move freely and without any other resistance excepting that of its own inertia.

QUESTION 26. *How can this be more clearly illustrated and explained?*

Answer. To make this clear, we will again suppose that we have a cannon-ball, *B*, fig. 3, suspended by a very long string so that it can move freely, and the arc in which it will be required to swing will not differ appreciably from a straight line. We will also suppose that we have a long cylinder, *C*, with a piston, *P*, and rod, *R*, fitted in it so that they can move freely in the cylinder—the rod *R* being attached to, or bearing against, the cannon-ball *B*. If, now, we were to admit steam or compressed air into the cylinder by the pipe *S*, of such a pressure that the force exerted on the cannon-ball is equal to its weight,

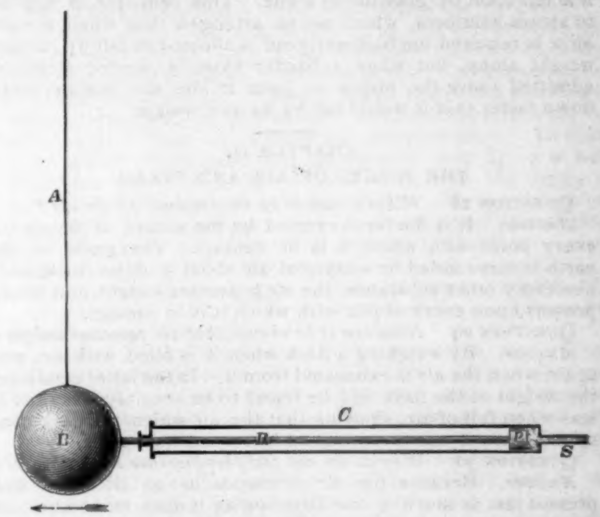


Fig. 3.

then, assuming that there is no friction of the piston, the ball would be moved in the direction in which the force or pressure on it is exerted, and in a given time it would acquire the same velocity that it would if it were allowed to fall freely. In the

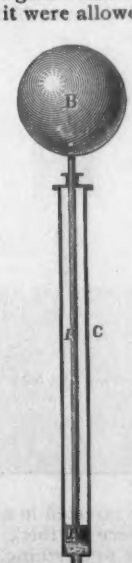


Fig. 4.

arc case, the pressure in the piston acting in a horizontal direction is the accelerating force, and in the other, the accelerating force is the attraction of gravitation or weight of the cannon-ball which acts downward. If these forces are equal

* This rule is correct only for bodies falling in a vacuum, but is approximately correct for heavy bodies falling in the atmosphere.

to each other the velocity and acceleration of the suspended ball in a horizontal direction will be the same as if it was allowed to fall vertically an equal distance.

If we had a vertical cylinder as shown in fig. 4 with a ball, *B*, piston *P* and rod *R*, then if the pressure in the piston was equal to its own weight and that of the rod and ball, the two forces, that is, the pressure under the piston acting upward and the attraction of gravitation acting downward, would just balance each other, and there would be no motion. If, however, the pressure against the piston was double that of the weight on it, then there would be an upward force equal to twice the weight of the parts, which would be resisted by their inertia alone. Consequently, under these conditions the cannon-ball would fall upward—if such an expression may be used—at the same velocity that it would fall downward by its own weight.

QUESTION 27. *If the force acting on a moving body is increased or diminished what effect does it have on the velocity.*

Answer. The velocity is in exact proportion to the force acting on it. If you double the force, you double the velocity. Thus, if the cylinder shown in fig. 4 was turned upside down, and a pressure was then produced on top of the piston equal to the weight attached to it, then there would be two forces acting downward on the cannon-ball—its own weight and that due to the pressure on the piston. If the two are equal then the cannon ball would fall at double the velocity that it would if acted upon by gravitation alone. This principle is applied to steam-hammers, which are so arranged that when a light blow is required the hammer-head is allowed to fall by its own weight alone, but when a harder blow is needed steam is admitted above the piston to force it and the hammer-head down faster that it would fall by its own weight.

CHAPTER II.

THE FORCES OF AIR AND STEAM.

QUESTION 28. *What is meant by the pressure of the air?*

Answer. It is the force exerted by the weight of the air on every point with which it is in contact. The globe of the earth is surrounded by a layer of air about 50 miles thick, and, like every other substance, the air possesses weight, and hence presses upon every object with which it is in contact.

QUESTION 29. *How can it be shown that air possesses weight?*

Answer. By weighing a flask when it is filled with air, and again when the air is exhausted from it. In the latter condition the weight of the flask will be found to be sensibly less than it was when full of air, showing that the air which the flask contained when it was first weighed increased its weight.

QUESTION 30. *Why do we not feel this pressure on our bodies?*

Answer. Because the air surrounds us on all sides, and presses just as much in one direction as it does in another, so that the pressures in different directions just balance each other, or are *in equilibrium*; but if the air presses on one side only of an object as it does when you suck the air from a tube closed at one end and you cover the open end with your tongue, the air then presses your tongue against the tube, and the one appears to adhere to the other; or if the air be sucked out of a

Fig. 5.

tube, one end of which is inserted in a liquid, the latter will be forced up the tube. A piece of thick leather under ordinary conditions will not adhere to anything, but if it be thoroughly wet and pressed hard against the surface of a smooth stone, so as to force out the air from under it, the stone, as nearly all school-boys know, can be lifted up if a string is attached to the leather. These phenomena are due to the pressure of the atmosphere; in the first case on one side of the person's tongue, pressing it against the mouth of the tube; in the second, to the weight of the air pressing on the surface of the liquid, forcing it into the vacuum in the tube, and in the last, to the same pressure on the top of the leather, causing it to adhere to the stone.

QUESTION 31. *What is the amount of the pressure of the atmosphere, and how is it measured?*

Answer. It is usually measured by the pressure on one square inch of surface, which, at the earth's surface, is 15 pounds.* If, for example, we have a cylinder, *A*, fig. 5, with an air-tight piston, *B*, fitted to it whose area is just one square inch, if through the tube *C* we exhaust the air from the cylinder above the piston, the air will press against the under side of the piston so that, if no power is required to overcome its friction in the cylinder, the pressure of the air will raise a weight of 15 pounds. The pressure of the air varies, however, as you ascend or descend from the surface of the earth, because as you go up on a mountain or in a balloon the layer of air above you becomes thinner, and, therefore, its weight and consequent pressure are diminished; and as you descend, as in a deep mine, the layer is thicker, and its pressure consequently greater.

QUESTION 32. *What is steam?*

Answer. In the dictionary, steam is defined as "the elastic, aëriform fluid into which water is converted, when heated to the boiling point," or, in other words, steam is water changed by means of heat into a gas. It is the transparent fluid which escapes from the mouth of a tea-kettle when the water in it is boiling. The visible cloud which escapes from boiling water and is seen in the form of mist at the mouth of the exhaust-pipe of a steam engine is not true steam. It is rather small particles of water, into which the steam has condensed through contact with the cold air. True steam is invisible, as we may observe near the mouth of a kettle or the exhaust-pipe of an engine from which we know it is escaping. At every temperature there is formed from water, on its surface, vapor of which the clouds are formed at all seasons of the year. This change of water into vapor, or evaporation of water, takes place at low temperatures only on its surface, however. But if we heat water in a vessel to a temperature of 212 degrees Fahrenheit, then the inner particles of the mass of water (lying on the heating surface of the vessel) are changed into steam, and rise to the surface in bubbles, which is the phenomenon we call *boiling*.

QUESTION 33. *If water is heated in an open vessel, what occurs?*

Answer. It continues for some time to increase in temperature, and the evaporation becomes more and more rapid. At length bubbles of vapor break out and reach the surface, and the process of boiling or ebullition has begun. When this takes place, the temperature of the water ceases to rise, and it remains stationary until all the water has boiled away, the only difference being that if the supply of heat be very great the process is very rapid, and if the supply of heat be small the process is very slow. The point at which ebullition commences is called the *boiling point*

QUESTION 34. *On what does the boiling-point depend?*

Answer. Chiefly on the pressure on the surface of the water, but to some extent upon the purity of the water. Thus, boiling, which takes place at 212 degrees under the ordinary atmospheric pressure, in lighter air, as on high mountains, takes place at a much lower temperature than on lowlands, and so water boils in a glass tube from which the air has been exhausted by the warmth of the hand, that is, at 92 degrees.

QUESTION 35. *What is the pressure of steam which escapes from boiling water in an open vessel?*

Answer. It is exactly equal to the pressure of the atmosphere in which it is boiled. Ordinarily, this is 15 lbs., and the boiling-point 212 degrees; but if we go up on a mountain where the atmospheric pressure is only 10 lbs. per square inch, the water will then boil at a temperature of 193.3 degrees, and the steam which escapes will have the same pressure as the atmosphere, or 10 lbs. per square inch. On the other hand, if we could go down into a mine where the atmospheric pressure was 20 lbs. per square inch, the water would not boil until it was heated to 228 degrees, and the pressure of the escaping steam would then be 20 lbs. per square inch.

QUESTION 36. *If water is boiled in an enclosed vessel, like a covered tea-kettle or a steam-boiler, what occurs?*

Answer. The steam rises and fills the space above the water, and, if it cannot escape, increases in pressure. The temperature of both the water and the steam rises with the pressure, and will continue to do so as long as the heat is increased, or until the steam can escape, or the vessel is exploded. The boiling point also rises as the steam pressure increases.

*In common practice it is generally taken at 15 lbs. per square inch, but the average atmospheric pressure is, more accurately, 14.7 pounds.

QUESTION 37. *How can this effect be illustrated?*

Answer. It can be shown if we take a glass tube *T*, fig. 7, closed at its lower end, and put a small quantity of water in it, and then force a cork, *C*, which fits the tube, or a wad of cotton saturated with tallow, down on top of the water, and then hold the lower end of the tube over a spirit lamp or gas flame, and

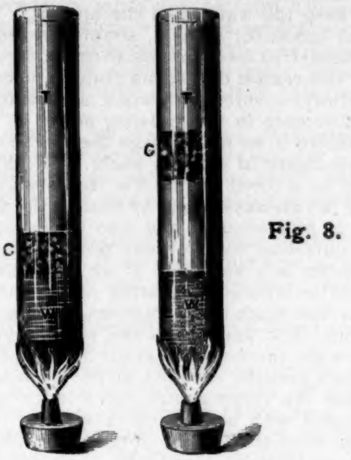


Fig. 7. Fig. 8.

heat it slowly, so as not to crack the glass tube. Bubbles of steam will then form at the bottom of the water, as shown in fig. 8. These will rise to the top, and will soon force the cork or wad of cotton upward with more or less violence, in proportion to the tightness with which it fits the tube, and the rate at which the water is boiled.

QUESTION 38. *Is there any pressure which corresponds to the temperature of steam and water?*

Answer. Yes. There is a fixed pressure for every temperature, when steam is in contact with water, and its pressure cannot be increased or diminished without at the same time heating or cooling the water, and the higher the temperature of the water the greater will be the corresponding steam pressure. Thus water at 212 degrees produces steam with a pressure equal to that of the atmosphere; at 240 degrees, the steam will have a pressure of 25 lbs. per square inch, or 10 lbs. more than the atmospheric pressure; at 281 degrees, a pressure of 50 lbs.; and at 328 degrees, 100 lbs. As this relation of pressure to temperature is fixed, if we know the one we can tell the other. This is true, however, only where the steam is in contact with water, when it is called *saturated steam*. If it is separated from water, it may be heated to a higher temperature without increasing its pressure in the same proportion, and it is then called *superheated steam*.

QUESTION 39. *How is the pressure of steam measured?*

Answer. In the same way as that of the atmosphere—that is, by the force exerted on one square inch of surface. Thus, if steam is admitted into the cylinder *A*, fig. 9, under the piston *B*, whose area is equal to one square inch of surface—sup-

Fig. 9.

posing, as we did before, that no power is required to overcome its friction in the cylinder—then, if the pressure of the steam thus admitted below the piston would just balance the pressure of the atmosphere above it, the steam pressure would be equal to 15 lbs. If, besides overcoming the pressure of the atmosphere, the steam below the piston would raise a weight, *W*, of 15 lbs., then its pressure per square inch would in reality be equal to 30 lbs. per square inch. If the pressure of the atmosphere is *included* or *added to* that of steam *above* it, it is called its *absolute pressure*. In ordinary high-pressure steam engines, however, the steam must always overcome the pressure of the atmosphere, and therefore the only part of the pressure which is effective is that above, or by which it exceeds, the atmospheric pressure. This is therefore called the *effective* or *working pressure*. For example, although the steam admitted under the piston in fig. 9 has an absolute pressure of 30 lbs. per square inch, yet it will only raise a weight of 15 lbs., because it must first overcome the pressure of the air on the other side of the piston. The pressure of the steam used in most stationary and in locomotive engines is, therefore, measured by its pressure above the atmosphere. That is, if steam introduced under the piston in fig. 9 will raise a weight of only 15 lbs., we say it has a pressure of 15 lbs. per square inch; if it will raise 50 lbs., its pressure is said to be 50 lbs. per square inch, and so on. The pressure of the atmosphere is disregarded, and all steam-gauges used on locomotives are graduated in that way. In speaking of steam pressure in future, therefore, unless otherwise specified, we shall mean *effective* or *working* and not *absolute* pressure.

QUESTION 40. *What is meant by the expansion of steam?*

Answer. In all gases a repulsion is exerted between the various particles, so that any gas, however small in quantity, will always fill the vessel in which it is held. Steam possesses this same property, and, if placed in any vessel, the particles in endeavoring to separate from each other will exert a force on all its sides. This force we call the steam pressure. To illustrate this we will suppose that the cylinder *A* in fig. 9 is half filled with steam of 30 lbs. pressure. If, now, the supply of steam is shut off, the steam in the cylinder will expand so as to push the piston upward, but with a somewhat diminishing force, the nature of which will be explained hereafter.

QUESTION 41. *What is meant by the volume of steam?*

Answer. It means the space which the steam occupies.

QUESTION 42. *What is the proportion which exists between the volume and the absolute pressure of steam?*

Answer. If the temperatures remain the same they are INVERSELY PROPORTIONAL TO EACH OTHER; that is, the one increases in the same proportion as the other diminishes. If we admit steam of 30 lbs. pressure per square inch into the cylinder *A*, fig. 9, and then cut off the supply by closing the cock *C* and allow the steam in the cylinder to expand to double its volume by pushing the piston to the end of the cylinder, the steam pressure will then be only 15 lbs.; if it should expand to three times its volume its pressure would be only one-third, or 10 lbs. per square inch. This method for calculating the pressure of steam after it has expanded is correct only for the *absolute* and not for the *effective* pressures of steam. In order to ascertain the effective pressures of steam after expansion, it is only necessary to make the calculation with the absolute pressure and deduct the atmospheric pressure from the result. If, after being thus expanded, the piston be pushed down again so as to compress the steam into its original space, its pressure will again be 30 lbs., providing no heat has been lost in any way.

QUESTION 43. *With a cylinder of any given stroke* how can we determine approximately the pressure of the steam after expansion for any given point of cut-off?* †

Answer. BY MULTIPLYING THE ABSOLUTE PRESSURE PER SQUARE INCH OF THE STEAM IN THE CYLINDER BEFORE IT IS CUT OFF, BY THE DISTANCE FROM THE BEGINNING OF THE STROKE AT WHICH IT IS CUT OFF, AND DIVIDING THE PRODUCT BY THE WHOLE LENGTH OF THE STROKE. Thus, if we have a cylinder whose piston has a stroke of 24 inches, if we cut off the steam at 8 inches, and have an ABSOLUTE pressure of 90 lbs. in the cylinder, the calculation is as follows:

$$\frac{90 \times 8}{24} = 30 \text{ lbs. final pressure.}$$

If we cut off at 10, 12 and 15 inches, the final pressure would be $37\frac{1}{2}$, 45 and $56\frac{1}{4}$ lbs., respectively. To get the effective pressure deduct the atmospheric pressure from this result.

QUESTION 44. *What is the proportion between the volume of steam and that of the water from which it is formed?*

Answer. At the pressure of the atmosphere (15 lbs.) each cubic inch of water will make 1,610 cubic inches of steam. At

*The *stroke* of a piston is the distance it moves in the cylinder, and in ordinary engines is always twice the length of the crank, measured from center to center of the shaft and crank-pin.

†The steam is said to be *cut off* when the steam-port or opening by which steam is admitted to the cylinder is closed by the valve.

double that pressure, or 30 lbs. absolute pressure, it will make a little more than half as much, or 838 cubic inches; at four times, or 60 lbs. absolute pressure, 437 cubic inches, or a little more than a fourth as much as at the pressure of the atmosphere.

QUESTION 45. *Why is it that the quantity of steam at high pressures is somewhat greater than in inverse proportion to the pressure?*

Answer. Because the boiling-point of water, as has already been explained, is higher as the pressure increases, and therefore the temperature of the steam produced at such pressure is also higher than at lower pressures; and, as all gases are expanded by heat, therefore the volume of steam at the higher pressures is somewhat greater than in inverse proportion to its pressure, on account of being somewhat expanded by its high temperature. To make this plain, if we take a cubic inch of water and convert it into steam of atmospheric pressure, its volume will be 1,610 times that of the water and its temperature 212 degrees.* If we convert this quantity of water into steam with a pressure double that of the atmosphere, the volume of the steam will be 838 times that of the water and its temperature will be 250.4 degrees. If the volume of the steam were exactly *inversely proportional* to the pressure, the cubic inch of water at double the atmospheric pressure would make only 805 cubic inches of steam; but, as the boiling-point at that pressure is 38.4 degrees higher, the steam is expanded 33 cubic inches by the increase of its heat due to the higher boiling-point.

QUESTION 46. *What is meant by the condensation of steam?*

Answer. It is the reconversion of steam into water by cooling it, or depriving it of part of its heat. It has been shown that the temperature of water must be raised to a certain point to generate steam of a given pressure. If the process is reversed, and we deprive the steam of a part of its heat, some of the steam is then at once reconverted into water, or *condensed*, and the pressure of that which remains will be reduced just in proportion as the heat is lost. When the temperature gets below 212 degrees under atmospheric pressure, all the steam will be condensed. As the useful work which steam can do in an engine is due to its pressure, which, in turn, depends on its temperature, any loss of heat will diminish its effective power. For this reason, all waste of heat from a steam engine should, as far as possible, be prevented.

QUESTION 47. *How is the heat of the steam wasted or lost in an ordinary steam engine?*

Answer. It is wasted in three ways: first, by *conduction;* second, by *convection;* and third, by *radiation.*

QUESTION 48. *What is meant by these three terms?*

Answer. (1.) By *conduction* is meant that phenomenon which is manifested when we put one end of a metal bar, two or three feet long, into the fire and heat it. The heat is then gradually conveyed from one particle of the metal to that next to it until finally the end of the bar farthest from the fire may become so hot that it cannot be touched. The heat is then said to be *conducted* through the bar. In the same way the metal of the boiler, pipes, cylinders and other parts of the engine becomes heated on one side, and the heat is thus conveyed to the outside of these parts.

(2.) The air with which they are surrounded then becomes heated, and, being then lighter than the cold air, it rises and is again replaced with air which is not heated. In this way the heat is *conveyed* away by the air, and this phenomenon is therefore called *convection*,

(3.) If an iron plate be placed in front of an ordinary grate fire, three or four feet from it and exposed to the rays of heat from the fire, it will soon become so hot that you cannot bear your hand on it. If you place your hand between the iron plate and the fire you will find that only the side of your hand which is exposed to the fire will become hot; showing that the air between the plate and the fire is not nearly so hot as the plate soon becomes, and therefore that the heat is not conveyed to the plate by the air between it and the fire, but by the rays from the fire. This phenomenon is called *radiation.* The same thing occurs from any hot body, as, for example, a coil of steam pipe for heating a room, a steam boiler, or cylinder of an engine.

QUESTION 49. *Is there any difference in the conducting and radiating power of different substances?*

Answer. Yes, very great. The difference in the *conducting* power of wood and iron is shown if we place one end of a bar of each in the fire. The wood will be consumed without warming the bar more than a few inches from the fire, whereas the iron will soon become hot two or three feet from the fire. Owing to the difference in the conducting power of cotton and wool, we wear cotton clothing in summer and woolen in winter, because cotton allows the heat of the body to be conducted away from it, whereas woolen cloth prevents to a great degree this loss of heat. For the same reason, the venders of roasted chestnuts on our streets wrap them in a piece of blanket to keep them hot, that is, to keep the heat in; and in summer we wrap ice in the same way to keep it cold, that is, keep the warmth of the air out. The wool, being a very bad conductor of heat, simply prevents the heat from being transferred from the inside to the outside, and *vice versa.* It is for this reason that steam boilers, pipes and cylinders are nearly always covered with wood, and sometimes with felt.

The difference in the *radiating* power of various substances can be shown if we take a large thermometer and heat it up to the temperature of boiling water. If this thermometer is hung up in a room having the temperature of melting ice, it will lose in two ways—first, by heating the air which surrounds it, that is, by *convection*, and also by *radiation.* In order to confine ourselves to the latter process, we will suppose that the chamber is a vacuum. If we first cover the bulb of the thermometer with a thin coating of polished silver, and then ascertain how much heat it radiates in a minute, and then coat it with lamp-black and repeat the same experiment—that is to say, allow the thermometer at the boiling-point to cool for one minute in a vacuum chamber at the freezing-point—it will be found that the thermometer loses much more in a minute when coated with lamp-black than it did when coated with silver, showing that much more heat is radiated from a surface covered with lamp-black than from polished silver. Generally, it may be stated that polished metals radiate much less heat than surfaces which are not polished.* For this reason, as well as for ornament, locomotive and other boilers and cylinders are usually covered with Russia iron or polished brass.

CHAPTER III.

ON WORK, ENERGY AND THE MECHANICAL EQUIVALENT OF HEAT.

QUESTION 50. *For what purpose are all steam engines used?*

Answer. They are used to produce *motion*, which is opposed by some *resistance.* Thus, if an engine is employed to raise grain from a railroad car to the top of a warehouse, it must produce motion, which is resisted by the weight of the grain; if it is used to saw wood, it must give motion to the saw, which is resisted by the fibers of the wood; a locomotive engine must produce motion of a train of cars, which is resisted by the air, the friction of the journals and the rolling of the wheels on the track; if the locomotive is employed on a grade or incline, besides the frictional resistance referred to, it must overcome that due to its own weight and that of the train, which is gradually lifted as it ascends the incline. In producing motion opposed by some resistance an engine is said to be doing "*work.*"

QUESTION 51. *Can this work be accurately measured?*

Answer. Yes; but in order to measure anything we must first establish some accurate standard or unit of measurement. Thus, we say a bar of iron is so many inches long, or a road is so many miles long. In like manner we speak of so many seconds, or minutes, or hours, or days, or years, when we speak of time. So it is necessary, in order to estimate or measure "*work*" in a strictly scientific manner, for us to fix upon some accurate standard or unit. In this country and in Great Britian the unit agreed upon for this purpose is the amount of power required to raise ONE POUND ONE FOOT, and is called a *foot-pound.* If we raise one pound two feet we do two foot-pounds of work; if three feet, three foot-pounds, and so on. Again, if we raise a weight of two pounds one foot high, we likewise do two foot-pounds of work; or if we raise it two feet high, we do four foot-pounds, and so on. In order to determine the amount of work done, we must MULTIPLY THE MOTION PRODUCED (*in feet*) BY THE RESISTANCE (*in pounds*), AND THE RESULT WILL BE THE WORK DONE IN FOOT-POUNDS.

QUESTION 52. *How many foot-pounds of work are performed in a pile-driving machine in raising a weight of 1,200 lbs. 24 feet?*

Answer. $1,200 \times 24 = 28,800$ foot-pounds.

QUESTION 53. *When this weight is raised, is the force which was exerted in raising it annihilated or lost?*

Answer. No; because the weight has the capacity of doing

* More accurately, 213.1 degrees, if we call the atmospheric pressure lbs.

* The account of the above experiment is copied from Balfour Stewart's very excellent little book, "Lessons in Elementary Physics," of which, and the same author's "Elementary Treatise on Heat," the writer has made frequent use.

an equal amount of work when it falls, from the momentum* it acquires in falling. This *power of doing work* which it acquires in falling is called *energy*. Now, although the weight has no motion-producing power when it is raised to the top of the machine, yet, obviously, such action is then *possible* which, when it rested on the earth, was not possible. It has no energy as it hangs there dead and motionless; but energy is possible to it, and we might fairly use the term *possible energy* to express this power of motion which the weight possesses,† and which is therefore called *potential energy*. As soon as the weight is allowed to fall it acquires a greater velocity the farther it falls, and its potential energy thus becomes and is called *actual energy*.

QUESTION 54. *How do we explain such phenomena as the heating of a car-axle while turning under a car, the heating of brake-blocks when the brakes are applied to car-wheels, the heating of an iron rod by hammering, and of a turning tool when cutting a piece of metal?*

Answer. All of these phenomena are due to the fact that the *actual energy* of motion is converted into heat, as has been repeatedly proved by many able and ingenious investigators and experiments.

QUESTION 55. *When the weight of the pile-driver falls, is its energy also converted into heat?*

Answer. A part is expended in compressing the material into which the pile is driven and in overcoming the friction of the earth against the pile, each of which efforts develops heat, and another portion is converted into heat by the impact or blow of the falling weight on the head of the pile.

QUESTION 56. *Is all energy convertible into heat and heat into energy?*

Answer. Yes. Science has demonstrated very clearly that they are mutually convertible.

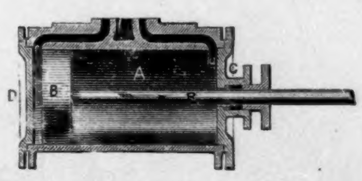
QUESTION 57. *Has it been ascertained how much heat is equivalent to one foot-pound of work?*

Answer. Yes. It has been found, from the most carefully-made experiments that the amount of heat which is required to raise the temperature of one pound of liquid water by one degree of Fahrenheit ‡ is equivalent to 772 foot-pounds of work. It must be remembered that this is the theoretical equivalent of heat, and that only a very small proportion of this amount of work is ever realized from the heat developed by the combustion of fuel.

QUESTION 58. *If, then, heat is convertible into work and work into heat, can the transmutation of the heat of the steam in the cylinder of an engine into work and the reverse process be explained?*

Answer. Take a cylinder, fig. 10, and, in order to make the conditions of the experiment as simple as possible, imagine it to be placed in a vacuum. Now let saturated steam be admitted under the piston so as to fill the cylinder half full at an

Fig. 10.



absolute pressure of 100 lbs. If we will allow this steam to expand to double its volume and raise the piston *without doing any work*, and then repeat the experiment with a load of 50 pounds on the piston, whose area is one square inch, it will be found that the temperature of the steam is sensibly less, after lifting the weight, than in the previous experiment, in which it expanded without doing work, showing that part of the heat was abstracted from the steam by doing work, or, in other words, was converted into work. If then, after the steam has expanded and lifted the weight, we press the piston down so that the steam under the piston is compressed to its original volume, we shall find that its temperature is the same as before, as the work done in compressing it is converted into heat. In these experiments it is assumed that there is no friction of the piston, nor loss of heat from radiation or conduction. The same phenomena can be observed in machines used for compressing air. In these, the air is heated to so high a temperature when

* Momentum is not a very exact term, but is used here because it ordinarily conveys the idea we wish to express.

† Tyndall's "Heat Considered as a Mode of Motion."

‡ Thermometers are divided into different scales. The one called the Fahrenheit scale, after its originator, is the one ordinarily used in this country.

it is compressed that it is sometimes necessary to cool the cylinders by circulating a current of cold water around them.

QUESTION 59. *What practical relation is there between the convertibility of heat into work and the conducting and radiating properties of different substances explained in answer to Question 49?*

Answer. The fact that heat is only another form of energy, or "the power of doing work," indicates that its loss by conduction or radiation lessens that power just as much as or more than the loss or waste of coal would, and therefore every effort should be made to protect the different parts of engines from loss of heat by covering them with substances which conduct or radiate very little heat. Care should also be taken to exclude cold air from circulating in contact with these parts, and excepting for supporting combustion, the nature of which will be explained hereafter, it should be excluded from the heating surface of boilers.

QUESTION 60. *What is meant by the term* LATENT HEAT OF EVAPORATION?

Answer. By *latent heat* is meant that heat which *apparently* disappears when water or other liquids are vaporized. Thus, it is found that if any quantity of water is converted into steam at any pressure, it is necessary not only to heat the water to a temperature equivalent to that of the steam, or to the boiling-point, but after the water has reached that temperature an additional amount of heat must be added in order to keep up the process of boiling. Notwithstanding this addition of heat to the water, the temperature of the steam produced will not be higher than that of the boiling water, thus showing that a considerable quantity of heat is absorbed, the only effect of which is to change the water into a gas or steam. This apparent disappearance of heat can be shown if we take a pound of boiling water whose temperature is 212 degrees and mix it with a pound of ice-cold water at 32 degrees temperature. The result will be a mixture of two pounds of water of a mean temperature of 122 degrees. If now we convert a pound of water into steam at atmospheric pressure, the steam will heat 6.37 lbs. of ice-cold water up to 122 degrees, showing that a pound of steam at atmospheric pressure contains over six times as much heat as a pound of water of the same temperature as indicated by a thermometer. A similar apparent disappearance of heat occurs when other liquids are evaporated, and when ice or any other solid is converted into a liquid.

QUESTION 61. *What is the explanation of these phenomena?*

Answer. The exact reasons which will explain them fully are probably not yet clearly understood, but it is at least extremely probable that when any substance is changed from a solid to a liquid, or from a liquid to a gaseous condition, "a large portion of the heat is spent *in doing work* against the force of cohesion."* The particles of solid bodies, as we know, are so united that it requires more or less force, according to the nature of the substance, to tear them apart. Now, we can conceive that the heat is changed into a form of energy, and in that condition resists this attraction of the particles to each other, and that being thus transformed it has lost the capacity of expanding the mercury in the thermometer. A similar effect takes place when a liquid is converted into a gas. In the former condition the particles move freely about each other and have little or no attraction for each other, but when it becomes a gas they have a *repulsion from* each other. The heat is thus converted into the energy of repulsion, and therefore is in reality no longer in the condition of heat and consequently does not affect the thermometer. We can illustrate this by supposing that, by using steam, heat is converted into work by raising the weight, or drop as it is called, of a pile-driving machine. When the weight is raised to the top of the guides from which it falls, although, as already explained, the heat is converted into *potential energy*, yet if we attached a thermometer to the drop we would not find that it was any warmer than before the drop was raised. If it were possible to make an instrument sufficiently sensitive to indicate an instantaneous change of temperature in the weight while falling, we would not find any increase of its temperature at the instant it had acquired its greatest momentum and just before it struck the object under it, although its potential energy would at that instant be converted into *actual energy* of motion. If, however, the weight should strike an unyielding object, its actual energy would at once be reconverted into heat, which our thermometer would indicate. The phenomenon of what is called latent heat of evaporation seems to be very similar to that described—the heat when the water is changed from a liquid to a gaseous condition is transformed into energy, which, as already stated, has no effect upon the mercury of the thermometer.

* Balfour Stewart on the Conservation of Energy.

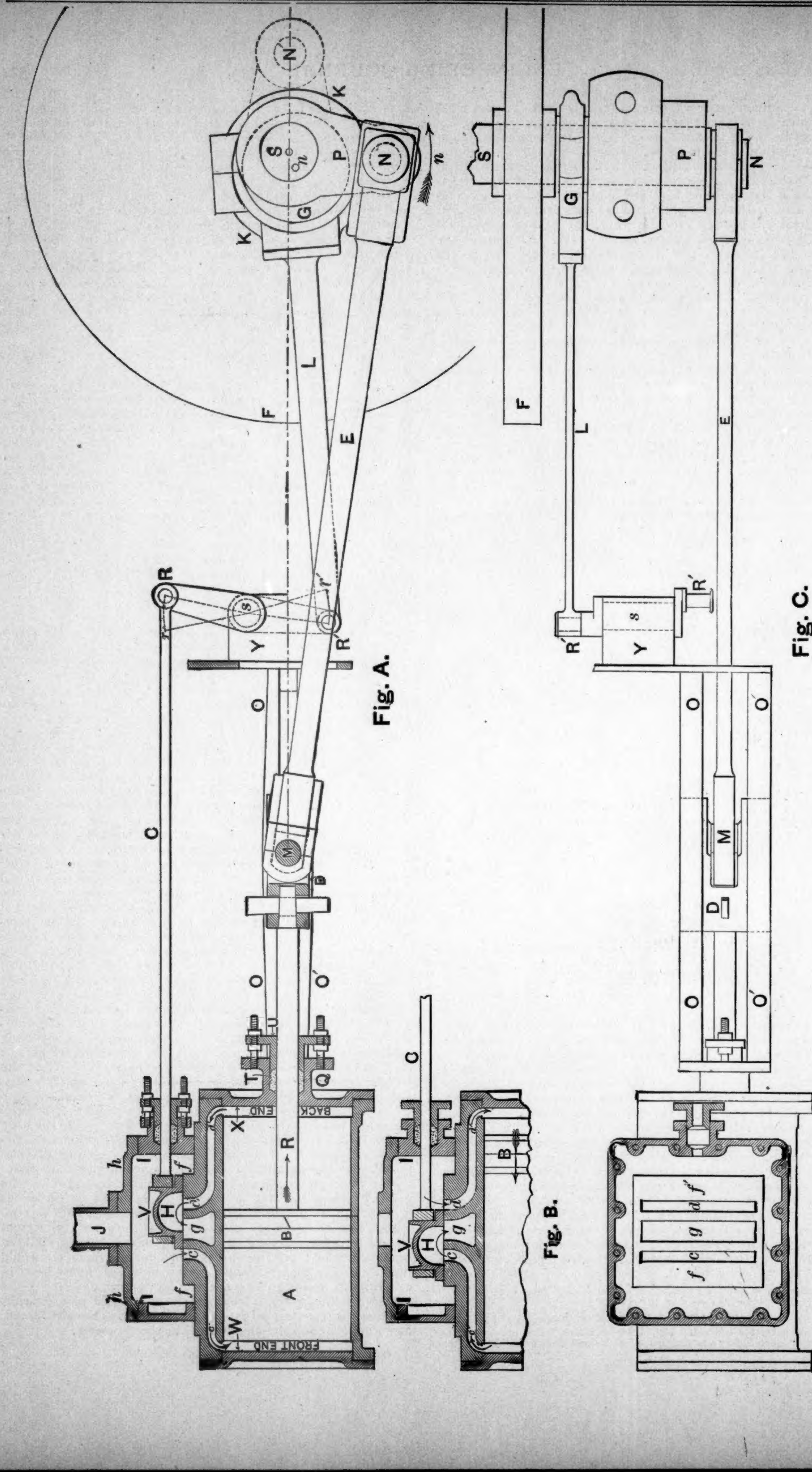


Fig. A.

Fig. B.

Fig. C.

PLATE I.—CATECHISM OF THE LOCOMOTIVE

QUESTION 62. ***What is meant by the* TOTAL HEAT *of steam?***

Answer. The "total heat of steam" is a phrase used to denote the sum of the heat required to raise the temperature of water from some given point up to the boiling-point due to a given pressure, and of the heat which disappears in evaporating one pound of water under a given pressure (or *latent heat of evaporation*). Thus, the latent heat of one pound of steam at atmospheric pressure (14.7 lbs.) is 966.1 units; and 212 units of heat are necessary to raise water from zero to the boiling-point; therefore, the total heat counted from zero of steam of atmospheric pressure is 1,178.1 units. At 100 pounds absolute pressure the latent heat is 885.5 and the sensible heat 327.9 degrees; therefore the total heat measured from zero is 1,213.4 units.

CHAPTER IV.

THE STEAM ENGINE.

QUESTION 63. *What is the motive power employed in ordinary steam engines?*

Answer. The expansive force of steam.

QUESTION 64. *How is this expansive force of steam applied?*

Answer. It is applied by admitting it into a *cylinder* (*A*, fig. 11) in which a *piston*, *B*, is fitted so as to move air-tight from one end of the cylinder to the other. The steam, if admitted at *c*, will force the piston *B* to the opposite end* of the

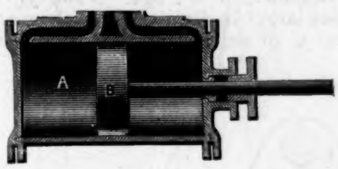


Fig. 11.

cylinder. When it has reached that end, if the steam is allowed to escape, and a fresh supply is admitted to the other end of the cylinder through the opening *D*, it will move the piston back again. In this way, by alternately admitting steam at one end and exhausting it from the other, the piston receives a *reciprocating motion*, which is communicated to the outside of the cylinder by a rod, *R*, which is called the *piston-rod*, which works air-tight through an opening in one of the *cylinder-covers*, or *cylinder-heads*, as they are usually called.

QUESTION 65. *How is this reciprocating motion of the piston converted into rotary motion?*

Answer. By connecting the end of the piston-rod *R* (fig. A Plate I) by another rod, *E*, called a *connecting-rod*, with a crank, *P*, which is attached to a revolving shaft, *S*. It is apparent that if the piston *B* is moved in the direction shown by the dart *R*, a rotary motion will be given to the crank in the direction of the dart *n*. When, however, the crank reaches the position shown by the dotted lines at *N'*, it is plain that a force applied to move the piston in either direction will no longer produce a rotary movement of the crank and shaft. The same thing will occur when the crank is in the opposite position. These two positions are called the ***dead-points*** of the crank.

QUESTION 66. *How is the crank of an ordinary steam engine carried past the dead points?*

Answer. A stationary engine usually has a large and heavy wheel, called a *fly-wheel*, *F F*, Plate I, which is attached to the shaft *S*. This wheel receives a sufficient amount of momentum from the crank, while the latter is moving from one dead-point to the other, to carry it past those points.

QUESTION 67. *How is the steam admitted to and exhausted from the cylinder?*

Answer. It is admitted through two channels, *cc'* and *dd''* called *steam-ways*, cast in the cylinder. These ways terminate in a smooth, flat surface, *ff'*, called the *valve-seat*. The openings of the steam-ports in the valve-seat are called *steam-ports*. Between them is another port or cavity, *g*, called the *exhaust-port*, which communicates with the open air. The form of these ports is long and narrow, as shown in fig. C, which represents a plan of the engine, or a view looking down from above it, with the top of the steam-chest and valve removed. Over these ports a valve, *V*, figs. A and B, called a *slide-valve*, which is usually made of cast-iron, with a cavity, *H*, on its under side—is fitted so that by moving it backward or forward it will alternately cover and uncover the two steam-ports. The valve and valve-seat are inclosed in a sort of box, *II*, made of cast-iron, called a *steam-chest*, into which steam is admitted from the boiler by a pipe, *J*. When the valve is in the position represented in fig. A, the front steam-port *c* is uncovered, and the steam is admitted to the front end of the cylinder, as indicated by the darts *c* and *c'*, and it thus forces the piston toward the back end, or in the direction of the dart *R*. If, when the piston reaches the back end, as shown in fig. B, the valve has been moved into the position shown, the back steam-port *d* will be uncovered, and steam will be admitted to the back end of the cylinder, as indicated by the darts *d* and *d'*. At the same time it will be observed that the front steam-port *c* and the exhaust-port *g* are both covered by the cavity *H* in the slide-valve, so that the steam which was admitted to the front end of the cylinder can now escape as indicated by the arrows *c' c*, through the steam-port into the exhaust-port *g*, and thus into the open air. By moving the valve alternately back and forth, steam is simultaneously admitted first to one end of the cylinder, and exhausted from the other, and *vice versa*.

Fig. 12

Fig. 13

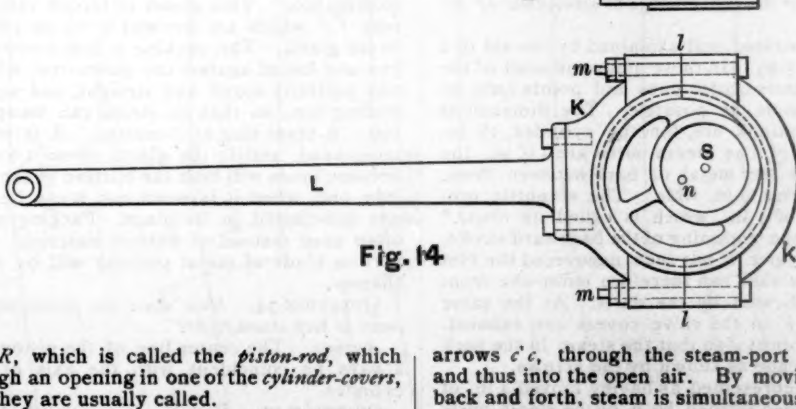


Fig. 14

QUESTION 68. *How is the slide-valve moved so as to admit and exhaust the steam at the right time?*

Answer. This is done by means of what is called an *eccentric*, *G* (shown separately in figs. 12 and 13), which is a circular disc or wheel, whose center *n* is some distance from that of the shaft *S*, to which it is fastened with keys or screws, and with which it revolves. The outside of the eccentric is embraced by a metal ring, *KK*, called an *eccentric-strap*, shown in fig. 14 and also in fig. A. This strap is made in two halves, which separate in the line *l l*. The two parts are fastened together by bolts, *m m*, which pass through lugs or projections cast on the straps, as shown. The outside, or the periphery,

*In all ordinary locomotives, the cylinders are so placed that the head *C* through which the piston-rod works is behind, and the other head *D* in front. The two ends of the cylinder are therefore designated the *front* and *back ends*, respectively.

of the eccentric, is accurately turned, and the inside of the strap is bored to fit it, so that the one can revolve inside of the other.

QUESTION 69. *How does an eccentric work?*

Answer. Its action is precisely like that of a crank, in fact it may be defined to be a crank with a crank-pin large enough to embrace the shaft.

QUESTION 70. *How is the motion of the eccentric imparted to the valve?*

Answer. A rod, *L*, called an *eccentric-rod*, is attached to the eccentric straps as shown in fig. 14. It is obvious from fig. *d*, that, if the eccentric revolves inside of the strap, it will impart a reciprocating motion to the rod *L*. The eccentric *G*, strap, *K*, and rod, *L*, are represented in fig. A. Before describing their operation, or rather their connection with the valve *V*, it is necessary to understand that in this country the slide-valves of locomotives are usually placed on top of the cylinders, in which position it is difficult to connect the eccentric-rod directly with the valve. For convenience, therefore, what is called a *rocker*, *R R'*, is placed between the cylinder and the main shaft of the engine. This rocker has two arms attached to a shaft, *s*, and the two arms have a vibratory motion about it, as indicated in the dotted lines *r R* and *R' r'*. The eccentric-rod *L* is attached by a pin, *R'*, to the lower arm of the rocker, and the valve is connected by the rod *C*, called the *valve-rod*, or *valve-stem*, to a pin, *R*, on the upper end of the rocker. It is obvious that, as the eccentric *G* revolves, a reciprocating or vibratory motion will be given to the rocker, which will be communicated to the valve by the valve-stem; and it is only necessary to fix the eccentric in the proper position on the shaft, in relation to the crank and piston, to give the valve the required motion for admitting and exhausting the steam to and from the cylinder at the right time.

QUESTION 71. *How can the action of the eccentric and the movement of the valve and piston during a complete revolution of the crank be shown?*

Answer. It can be illustrated and explained by the aid of a series of diagrams—figs. 15-29. In these diagrams most of the parts are represented by their center-lines and points only, so as to make them as simple as possible. The dimensions selected for these illustrations are, for the cylinder, 16 in. diameter and 24 in. stroke. The steam-ports are 1¼ in., the exhaust-port, 2½ in., and the metal or bars between them, which are called *bridges*, are 1⅛ in. wide. The eccentric produces a lateral movement of 4 in., which is called its *throw*.* In fig. 15, the piston is at the beginning of the backward stroke.

It will be seen that the valve *V* has then uncovered the first steam-port at *c*, and that steam can therefore enter the front end of the cylinder as indicated by the darts. At the same time, the exhaust-cavity *V* in the valve covers the exhaust-port *g* and the front steam-port *d* so that the steam in the back end of the cylinder can escape as shown by the arrows.

In fig. 16, the piston is represented as having moved 4 in. of its stroke; the valve has then opened both of the steam-ports wider. In fig. 17, the piston has moved 8 in. of its stroke, and the ports are now wide open, the front one to the steam and the back one to the exhaust. In fig. 18, the piston has moved 12 in., or is at half-stroke, and the valve has then moved to its extreme throw. In fig. 19, the piston has moved 16 in., and the valve has begun to return. In fig. 20, the piston has moved 20 in., and the valve has nearly closed the front port to the steam. In fig. 21, the forward stroke is completed, and the back steam-port is then slightly opened to admit steam into the back end of the cylinder for the return stroke. The front steam-port has also been made to communicate with the exhaust-port so that the steam in the front end of the cylinder will be exhausted before the piston begins to return.

Figs. 22 to 28 represent the positions of the piston and valve during the forward stroke, corresponding with those described for the backward stroke. The darts in the steam-ports in the figures represent the movement of the steam in each position of the piston and crank. Other darts show the direction in which the piston and crank are moving.

QUESTION 72. *How is the piston of a steam engine made to work steam-tight in the cylinder?*

Answer. The cylinder is first accurately bored out, and the piston has two metal rings around its periphery. Each of these rings is cut apart as shown in fig. A, plate I, so that they can be expanded by springs or other means to fit the cylinder. The open places are placed at different points on the circumference of the piston, so that the one opening is covered by the other ring, which prevents the steam from leaking through the openings.

QUESTION 73. *How is the piston-rod made to work steam-tight through the cylinder-head?*

Answer. By what is called a *stuffing-box*. This consists of a cylindrical chamber, *A A'*, figs. 30 and 31, which is made about 1½ inches larger in diameter than the piston-rod. This leaves a space ¾ of an inch wide all around the rod. This space is filled with hemp, *H*, or some other fibrous material, called *packing*, saturated with oil or melted tallow. This packing is compressed by a hollow cylinder, *C C*, called a *gland*, the inside of which fits the piston-rod P, and the outside the stuffing-box. This gland is forced into the stuffing-box by nuts *t t'* which are screwed down on a flange, *u*, *u'*, attached to the gland. The packing is thus compressed in the stuffing-box and forced against the piston-rod, which is made smooth and perfectly round and straight, and against the side of the stuffing-box, so that no steam can escape around the piston-rod. A brass ring or "*bushing*," *B*, is often put into the cylinder-head, and in the gland where it touches the piston-rod, because brass will bear the friction of the rod better than cast-iron, and, when it is worn out, it can be removed, and a new one substituted in its place. Packing made of metal is now often used instead of fibrous material. The construction of various kinds of metal packing will be described in a future chapter.

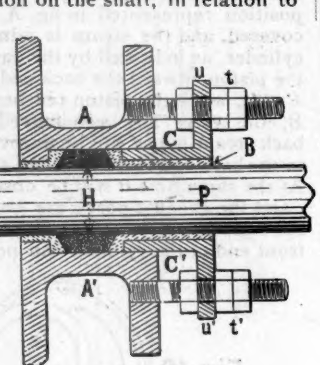


Fig. 30.

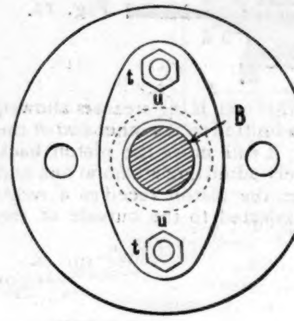


Fig. 31.

QUESTION 74. *How must the piston and piston-rod move in order to keep steam-tight?*

Answer. The center line of the piston and piston-rod must always be coincident with the axis or center line of the cylinder.

QUESTION 75. *How is the movement of the piston-rod affected by the connecting-rod?*

Answer. Excepting when the crank is at one of the dead-points, the center line of the connecting-rod is inclined to that of the piston-rod and axis of cylinder. Consequently, at all other points of the revolution, the connecting-rod has a tendency to either pull or push the end of the piston-rod downward, when the crank is turning in the direction that the hands of a watch or clock turn. If the crank turns the opposite way, as a locomotive wheel revolves when it is running ahead, the connecting-rod presses the end of the piston-rod upward.

QUESTION 76. *How is this action of the connecting-rod resisted?*

*There is some ambiguity in the use of the term *throw*. In Webster's dictionary it is defined as "the extreme movement of a slide-valve, also of a crank or eccentric, measured on a straight line passing through the center of motion." The definition of mechanical terms, in the edition of the dictionary quoted from, were prepared by the late Alexander L. Holley, so that no more eminent authority could be quoted for the usage of the term with this meaning. Nevertheless, the word *throw* is sometimes used to designate the distance from the center of a shaft to the center of a crank-pin or eccentric, which, of course, would be only one-half the extreme movement of a valve or piston.

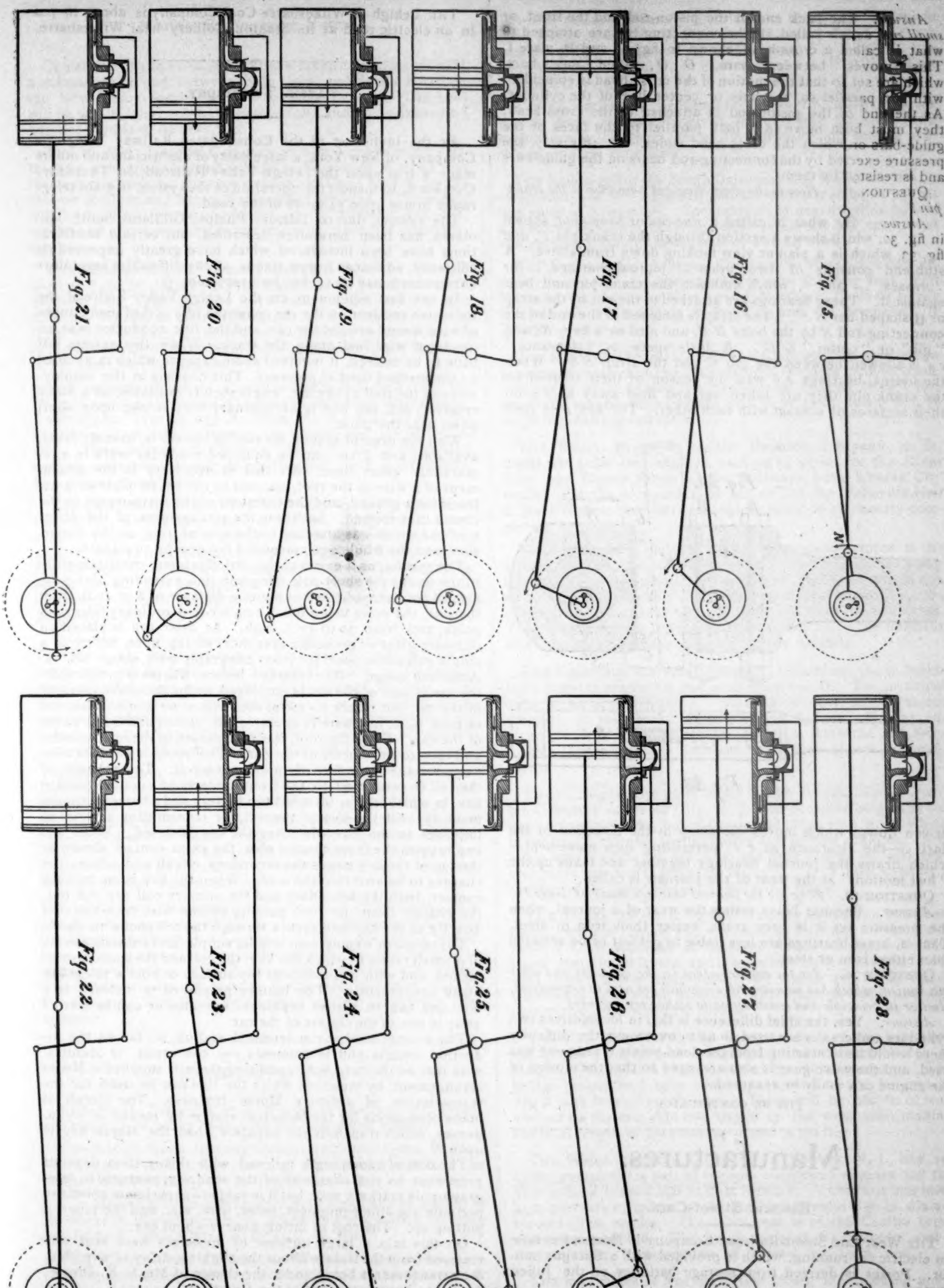


Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.
Fig. 25.
Fig. 26.
Fig. 27.
Fig. 28.
M

Answer. The back end of the piston-rod and the front, or *small end*, as it is called, of the connecting-rod are attached to what is called a cross-head, shown in figs. A and B, plate I. This moves between bars, *O O'*, called guide-bars, which are set so that the motion of the cross-head is coincident with, or parallel to, the axis or center line of the cylinder. As the end of the piston-rod is attached to the cross-head, they must both move in a path parallel to the faces of the guide-bars on which the cross-head slides. In this way, the pressure exerted by the connecting-rod bears on the guide-bars and is resisted by them.

QUESTION 77. *How is the connecting-rod connected to the crank-pin?*

Answer. By what is called a *stub-end* or *strap-head*, shown in fig. 32, which shows a section through the crank-pin *P*, and fig. 33, which is a plan or view looking down from above. A stub-end consists of two brass "journal-bearings," or "brasses," *a* and *b*, which embrace the crank-pin and bear against it. These bearings are attached to the rod by the strap or U-shaped bar *S S'*. The strap is fastened to the end of the connecting-rod *R* by the bolts *B B*, and also by a key, *K*, and "gib" or "cotter," *G G'*. A little space, or "clearance," *c c'* is allowed between the gib *G* and the strap *S S'*. When the journal-bearings *a b* wear by reason of their friction on the crank-pin, they are taken out and filed away at *f g*, on their surfaces of contact with each other. The key *K* is then

Fig. 32.

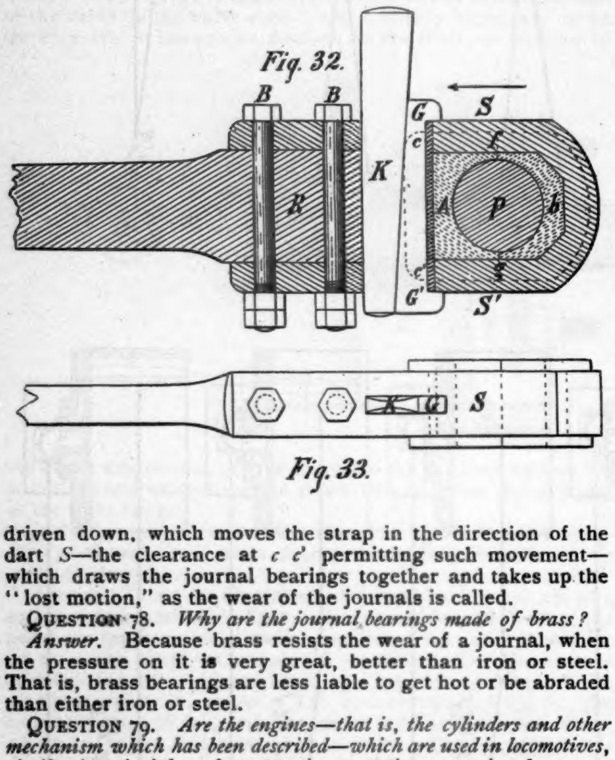


Fig. 33.

driven down, which moves the strap in the direction of the dart *S*—the clearance at *c c'* permitting such movement—which draws the journal bearings together and takes up the "lost motion," as the wear of the journals is called.

QUESTION 78. *Why are the journal bearings made of brass?*

Answer. Because brass resists the wear of a journal, when the pressure on it is very great, better than iron or steel. That is, brass bearings are less liable to get hot or be abraded than either iron or steel.

QUESTION 79. *Are the engines—that is, the cylinders and other mechanism which has been described—which are used in locomotives, similar in principle and construction to stationary engines?*

Answer. Yes, the chief difference is that in locomotives two cylinders and cranks are used so as to overcome the difficulty there would be in starting from the dead-points if only one was used, and the valve gear is also arranged so that the motion of the engine can easily be reversed.

(TO BE CONTINUED.)

Manufactures.

Electric Street-Cars.

THE West End Street-Railroad Company in Boston has now an electric car running, which is provided with a Sprague motor. Power is derived from storage batteries on the Julien system.

A NEW line has been opened from St. Catherines, Ont., to Thorold, 6 miles. The overhead-wire system is used, the electricity being generated at the terminus by a dynamo driven by water power.

THE Lehigh & Wilkesbarre Coal Company is about to put in an electric road at its Stanton Colliery near Wilkesbarre.

Train Telegraphy.

AT the invitation of the Consolidated Railway Telegraph Company, of New York, a large party of electricians and others made a trip upon the Lehigh Valley Railroad, on Thursday, October 6, to inspect the operation of the system of train telegraphy in use upon 54 miles of the road.

The system, due to Edison, Phelps, Gilliland, Smith and others, has been heretofore described, but certain modifications have been introduced which have greatly improved its efficiency, so that as it now stands, all the difficulties heretofore encountered may be said to be overcome.

In the first equipment on the Lehigh Valley Railroad the inductive receiver on the car consisted of a coil of many turns of wire wound around the car, and the line conductor was an insulated wire laid along the track. While this system left little to be desired, it involved some expense which is avoided by the method used at present. This consists in the employment of the roof of the car, where such is available, as a static receiver, and the line is an ordinary wire strung upon short poles near the track.

With the present system the roof of the car is, in most cases, available, and a car can be equipped ready for work in a remarkably short time. All that is necessary is the attachment of a wire to the roof, another to the swivel plate of a car truck for a ground, and the insertion of the instruments in the circuit thus formed. Such was the arrangement of the directors' car which was attached to the special train on the excursion, and the whole equipment did not occupy 10 minutes.

The system, as it exists to-day, briefly stated, consists mainly in the use of the short-pole telegraph line extending along the side of the railroad track at about a distance of 8 or 10 ft. from the line, the poles being much smaller than ordinary telegraph poles, and from 10 to 16 ft. high. At their top is placed an ordinary glass or porcelain insulator, strung upon which is a single galvanized steel (or iron) telegraph wire, about No. 12 American gauge. As remarked before, wherever practicable, the metal roof of the car is employed as the inductive receiver of the car, but where no metal roof exists, an iron or brass rod or tube ½ in. in diameter is employed, placed under the eaves of the car. From the roof, the wire passes to the instruments, and then to the wheels of the car. The roof, or bar, are connected to the secondary of an induction coil. The primary of the coil is connected to the front contacts of a double-pointed key, in which is also included the battery and a buzzer arrangement opposite the core of the coil, for transmitting a series of impulses to the line whenever the key is closed. When the key is upon the front contact also, the extra contact shown at the top of the key closes the secondary circuit and allows the charges to be sent into the roof. When the key is on its back contact, both the secondary and the primary coil are cut out, the charge from the roof passing by the wire from the roof directly to the key and thence through the telephone to earth.

The operator's equipment is quite simple, and consists merely of a small tablet to which the key, the coil and the buzzer are attached, and with just sufficient top surface to hold a telegraph blank conveniently. The battery employed is inclosed in a box and can be placed beside the operator or can be stowed away in one of the closets of the car.

The arrangement at the terminal station, so far as the induction circuits and instruments are concerned, is identical with that on the car; but in addition there is supplied a Morse arrangement, by means of which the line can be used for the transmission of ordinary Morse business. The circuit is made continuous for the induction system by means of a condenser, which transmits the impulses when the Morse key is open.

The cost of equipping a railroad with this system depends somewhat on the character of the roadway, nearness to telegraph-pole markets, etc.; but it is said to approximate about $50 per mile for line equipment, poles, wire, etc., and the labor of putting up. The cost of fitting a car is about $15.

On this trip, a large number of messages were sent and received from the train without the slightest delay of any kind, the arrangements being under the charge of Mr. S. K. Dingle, Assistant Superintendent of the Company.

One of the most striking demonstrations of the wide application of the system was the sending of a dispatch from the rapidly moving train to Mr. John Pender, of London, England, *via* the Atlantic cable.

Marine Engineering Notes.

Cramp & Sons in Philadelphia have taken a contract to build a steamboat to run between New York and Sandy Hook on the New Jersey Southern route to Long Branch. The boat will be 265 ft. long, will have twin screws and triple-expansion engines, and is to be very fast.

The W. & A. Fletcher Company in New York have the contract for a compound beam engine and a pair of Morgan iron feathering wheels for the new steamboat *City of Detroit*, for the Detroit & Cleveland Steam Navigation Company. The engine will have a high-pressure cylinder, 44 in. diameter and 8 ft. stroke and a low-pressure cylinder, 68 in. diameter and 12 ft. stroke.

The steamer *Gogebic*, recently launched from the Wheeler yard at Bay City, Mich., is 275 ft. keel, 40 ft. beam and 22 ft. depth of hold. Her engines were built by the Frontier Iron & Brass Works, of Detroit, and are of the triple-expansion type, with cylinders 20, 32 and 52 in. diameter by 40-in. stroke, being a duplicate of those furnished the steamer *Sitka*, launched at the same yard in August.

The steamer *Frank L. Vance*, recently launched from the Radcliff yard in Cleveland, O., has the following dimensions: Keel, 255 ft.; over all, 273 ft.; beam, 39 ft.; hold, 21 ft. She has three steel arches, two on the outside and one on the inside. There are two steel boilers, 9 by 15 ft., and a compound-engine, cylinders 28 and 50 in. diameter, with 45-in. stroke. She carries three masts.

The Quintard Iron Works in New York recently completed the engines for the lake steamer *Owego*. They are to work under a boiler pressure of 160 lbs., and the cylinders are 28 in., 42½ in. and 72 in. diameter, and 54 in. stroke. These engines are managed from the lower engine-room from the level of the shaft. Steam will be supplied by six boilers, each 11½ ft. diameter, and each having two of Fox's corrugated furnaces, 30 in. diameter and 6 ft. long.

The new steamer *Yakima*, built at Quayle's ship-yard in Cleveland, O., measures 275 ft. keel, 292 ft. over all, 40 ft. beam and 22 ft. hold. She has steel arches, is diagonally steel-strapped, and has a steel cord around the top. Her boilers are 13 by 12 ft., and the cylinders to her engine are 30 and 56 in., with 48-in. stroke. Her carrying capacity is 2,200 tons. She cost $125,000. She is fitted out with all modern improvements and is to be lighted with electricity.

Neafie & Levy in Philadelphia are to build a new steamer for the Oregon Improvement Company, for service on the Pacific Coast. The new steamer will be 230 ft. long, 34 ft. 6 in. beam and 25 ft. 3 in. depth, molded dimensions. She will be provided with the latest design of triple-expansion engines, with cylinders 20, 31 and 51 in. diameter, by 36-in. stroke. Boilers of steel, 4 in number, 10 ft. diameter by 11 ft. long, to carry 150 lbs. steam pressure.

The Harlan & Hollingsworth Company in Wilmington, Del., has begun a new steamboat to run on Chesapeake Bay for the Maryland Steamboat Company. The boat will be 200 ft. long, 31 ft. beam and 10 ft. deph of hold. The engine will be surface condensing, 42 in. diameter of cylinder by 10-ft. stroke. The paddle-wheels will be 22 ft. in diameter and have feathering buckets. She is to be finished in time for service next summer.

Manufacturing Notes.

The South Tredegar Iron Works in Chattanooga, Tenn., are running on heavy orders for rail-joints and spikes.

The Ensign Manufacturing Company at Huntington, W. Va., has begun to build a new erecting shop, 100 by 108 ft. The shops are now turning out 11 freight cars a day.

The Brown & Sharpe Manufacturing Company is adding to its works in Providence, R I., a new four-story brick building 195 by 51 ft., with a wing 40 by 40 ft. in size.

The Rhode Island Locomotive Works in Providence are building several ten-wheel freight engines for the Western & Atlantic Railroad.

The Elliott Car Works at Gadsden, Ala., are nearly ready for work. The buildings include two shops, each 50 by 200 ft., and a round-house 234 ft. diameter, to be used as an erecting shop.

A new rail-mill is nearly completed at the Edgar Thomson Steel Works at Braddock, Pa. It will have a capacity of 1,000 tons of rails per day, running double-turn. The new mill has three engines of 1,200 H. P. each, built by E. P. Allis & Co., of Milwaukee.

Riehle Brothers, proprietors of the Philadelphia Scale Works, have recently received large orders for track and wagon scales, charging scales for furnaces and testing machines, and are very busy.

The buildings for the South Baltimore Car Works are nearly completed, and it is expected that the works will be in operation early in November. Several rows of neat dwelling houses and stores are about completed close by, streets laid out, paved and curbed, forming the nucleus of a small town.

The Union Switch & Signal Company in Pittsburgh has recently received large orders for signals for the New York, New Haven & Hartford, the New York & Northern, the New Jersey Central, the Philadelphia & Reading and the Minnesota & Northwestern roads.

The Nashville (Tenn.) Iron, Steel & Charcoal Company is now pushing to completion two charcoal-iron furnaces in West Nashville, 12 by 60 ft., having two 5-in. stoves, 15 by 55, to each furnace, and two blowing engines with 36 by 48-in. steam and 48 by 48-in. blowing cylinders.

The Smith, Beggs & Rankin Machine Company in St. Louis will build two engines, each 24 by 48 in. for the River View and Eighth Street Cable Railways, both Kansas City roads. For the proposed light rail mill of the Belleville Nail & Steel Works, they have an engine, 30 by 60 in., nearly completed.

Very heavy steel plates are now being manufactured at the Linden Steel Works, near Pittsburgh. On October 1, among other large armor-plates for the United States Government's new cruisers one was rolled weighing almost 10,000 lbs., the dimensions being about 19 ft. long by 6 ft. wide and 2 in. thick. This is said by the Linden Steel Company to be the heaviest steel plate ever rolled on this side of the Atlantic.

The Columbus Machine Company, Columbus, O., is building a blowing engine for parties at Shawnee, O. The principal dimensions are as follows: Blowing cylinder, 84 in.; steam cylinder, 40 in.; stroke, 48 in.; weight, 85 tons. Similar engines are under construction for parties in Alabama and Kentucky. These engines embrace a number of late improvements

The silica-graphite paint made by the Joseph Dixon Crucible Company in Jersey City, N. J., was prepared originally for use on smoke-stacks, boiler-fronts and other iron work which is subject to extreme temperatures and sudden changes. It is a mixture of perfected graphite and pure linseed oil, and several years' use has thoroughly tested it. It is now used by a number of railroads and manufacturing firms.

The Union Switch & Signal Company is putting in a complete system of signals and interlocking switches for the Baltimore & Ohio Railroad at Camden Station, Baltimore. The tower contains 56 levers, and is tastefully built of pressed brick, with brown stone trimmings. The tracks are being relaid with heavy rails, stone ballasted, with frogs, switches and signals of the latest and best design.

The H. S. Hopkins Bridge Company in St. Louis has taken the contract for a new bridge over the Missouri River at Omaha, Neb., which is to be owned by a local company. The bridge proper will have seven spans, one of 400 ft., two of 250 ft. and four of 150 ft. each. There will be 900 ft. of iron viaduct on the east side and 925 ft. on the west side, making the total length of the structure about 3,350 ft.

The Watts-Campbell Company in Newark, N. J., has recently completed a pair of tandem compound engines for the Shrewsbury Thread Mill in East Newark. These engines have high-pressure cylinders 20 in. and low-pressure 36 in. diameter and 48 in. stroke. The valve-gear is of the Corliss type, somewhat modified. The fly-wheel is 25 ft. diameter and 6 ft. 2 in. face; it carries two 28-in. and one 10-in. belt.

The iron mines of Northern New Jersey are working more actively than for several years past. The Sherman and Bedell mines near Sparta have recently been re-opened by Cooper, Hewitt & Co. The Kishpaugh mine near Hope; the Dunker mine near Stockholm, and the Canisteer mine have also recently been re-opened. The Judson mine at Stanhope is being

worked by the Flanders Iron Company, and several mines have been opened along the line of the new Morris County Railroad.

AMONG the many improvements which the Pennsylvania Company is making in the shops at Fort Wayne, Ind., is the electric-light plant, which consists of six dynamos, two incandescent and four arc, capable of supplying 260 incandescent lights of 16-candle power, and 120 arc lights of 1,600-candle power. The arc lights will be used in the yards and as a general light in the shops, and in the machine-shop the incandescent light will be used at the machines instead of gas. All the shop offices will be supplied with incandescent lights. The Ball dynamo will be used.

THE new bridge over the Missouri River at Randolph, near Kansas City, built for the Chicago, Milwaukee & St. Paul Railway, is now completed. The total length of the bridge is 7,392 ft. There are three main spans of 400 ft. each, with trusses 50 ft. high and 23 ft. apart, each with 16 panels 25 ft. each. There is one deck span 160 ft. long, 1,545 ft. of iron viaduct, averaging 51 ft. in height above the ground and 22 ft. wide on top for double track; 2,775 ft. of timber trestle work, from 26 to 47 ft. high, and 1,590 ft. of pile bridge, from 15 to 26 ft. in height. There are five masonry piers. The four main piers supporting the 400 ft. spans rests upon rock, and the fifth pier rests upon pile foundation. The height of the channel piers is 92, 112 and 122 ft. The shore piers are 56 and 45 ft. in height. There are 82 pedestal piers, 14 ft. in height, resting upon pile foundations. These pedestal piers support the iron viaduct. The contractors for the pier foundations were Sooy-Smith & Co.; for the iron viaduct, M. Lassig; and for the bridge superstructure, the Keystone Bridge Company.

Proceedings of Societies.

New England Railroad Club.

THE regular meeting was held in Boston, October 12. The subject was Car Heating and Ventilation. Mr. J. G. Pennycuick, manager of the Pennycuick Heat & Ventilation Company, explained its system of heating cars and the operation of the automatic steam coupler controlled by the company.

Mr. Walter G. Chase explained the construction and working of the Mason reducing valve.

Mr. Nelson Curtis explained the Curtis pressure regulator.

Mr. Joseph A. Shinn described the system of car heating owned by the Safety Car Heating and Lighting Company of New York.

Mr. Sewall, of Portland, told of the successful practical test of heating a train with steam from the locomotive.

It was voted to discuss at the next meeting the subject of "Best Material for Axles, Journal Bearings and Lubrications."

American Institute of Electrical Engineers.

THE first monthly meeting of the season was held in New York, September 20. After dinner had been disposed of, as usual, a paper was read by Mr. Anthony Reckenzaun, of London, England, on Electric Street Cars, with Special Reference to Methods of Gearing. This paper was long and treated the subject in an exhaustive manner; it was followed by a discussion, in which many members took part.

New York Railroad Club.

A REGULAR meeting was held in New York, October 20, at which the subject of Car Heating and Lighting was discussed.

The proposition to change the name of the association from the Master Car-Builders' Club to the New York Railroad Club was approved.

Western Society of Engineers.

A REGULAR meeting was held in Chicago, October 4. Messrs. Moritz Lassig and George H. Bremner were elected members. Mr. L. P. Morehouse tendered his resignation as Secretary.

Mr. Lundie presented a short paper containing a formula, and its mathematical demonstration, for determining the Economical Proportions of Truss Bridges. A discussion of this paper, when printed, is invited by the author.

American Society of Railroad Chemists.

A MEETING of this Society was held in Omaha, Neb., early in October. The subjects brought up before the meeting for discussion were: Vehicles of Paint; Linseed Oil; Uniform Methods for the Analysis of Coal so as to ascertain its commercial value; Analysis of Car Brasses and Babbitt, and of Soap for Washing Cars; Best Methods of Preservation for Ties and Bridge-timber; Fireproof Paints; Fire-extinguishers; Methods of Heating and Lighting Cars. Lubricating oils and car paints were also brought up for consideration.

All the railroads having organized chemical departments are now represented in this Association.

Western Railroad Club.

A REGULAR meeting of this Club was held in Chicago, October 19. The best Form and Dimensions of Axle for 60,000-lbs. Cars was discussed by a number of members.

The Committee on Car Heating made a report recommending the appointment of a Committee to confer with railroad companies and secure the adoption of a uniform standard coupling for steam-heated cars. The report was adopted, and Messrs. W. Forsythe, J. N. Barr and W. A. Scott were appointed as the Committee.

General Time Convention.

THE fall meeting was held in New York, Oct. 12. The Committee on Uniform Train Rules presented its final report. The code of Telegraphic Train Orders and Rules was finally adopted with only two dissenting votes.

The questions of changing the system of payment for use of freight-cars (as recommended by the Car Accountants' Association) and of telegraphic distribution of accurate time were referred to Committees to report at the next meeting.

Association of North American Railroad Superintendents.

THE regular semi-annual meeting was held in New York, October 10. The Association voted to adopt the M. C. B. standard axle and journal-box, but refused to make any recommendation as to couplers for passenger cars. It also recommended the adoption of a general form of record for through trains.

Other subjects discussed were the Distribution of Time-tables; Demurrage on freight-cars; Charges for use of passenger-cars; Frogs and switches, and Track inspection.

Roadmasters' Association of America.

THE annual convention was held in Cleveland, O., October 11, and continued three days.

Discussions were had on Standard Weight of Rails; Guard Rails; Frogs and Switches; Rail-joints, and Hand-cars.

The following officers were elected: President, J. W. Craig; Vice-Presidents, I. Burnett, James Sloan; Secretary and Treasurer, H. W. Reed.

New England Roadmasters' Association.

THE annual meeting was held in Hartford, Conn., October 19, and lasted two days. The subjects discussed were: Guard Rails; Foot-guards for frogs and switches; Economy in maintenance of track, and Track on bridges.

The following officers were elected: President, W. A. Lane; Vice-President, J. R. Patch; Secretary, W. Ellis; Treasurer, George Nevens; Chaplain, E. W. Homer; Executive Committee, P. A. Eaton, L. H. Perkins, George Bishop.

Engineers' Club of Kansas City.

A REGULAR meeting was held October 3, J. A. L. Waddell, Vice-President, presiding; T. F. Wynne, Secretary *pro tem.* Messrs. E. W. Stern, Chas. H. Talmage, and Chas. W. Hastings were elected members.

The paper of the evening on the Construction and Operation of the Ninth Street Cable Railway, prepared by M. K. Bowen, was read by C. G. Wade.

Mr. Kiersted was invited and consented to read a paper at the next meeting, subject to be announced.

American Street-Railway Association.

THE sixth annual convention began in Philadelphia, October 19, with a large attendance. The report of the Executive Committee showed that the Association had increased its membership from 140 companies to 153 companies during the year. The report also spoke at length of the labor troubles of the year.

Mr. C. A. Richards, of Boston, read an elaborate paper on Roadway Construction, which was followed by a long discussion.

Mr. William Wharton, Jr., of Philadelphia, read a paper on Electricity as a Motive Power. He treated of the methods of transmitting power by means of overhead wires, by conduits and by storage batteries, arguing in favor of the latter method.

F. J. Sprague, of the Sprague Electric Railway & Motor Company, also spoke in the same vein.

A paper upon Motors Other than Cable or Electricity, prepared by D. Atwood, of Milwaukee, was also read.

On the second day Mr. Moses Humphrey, of Concord, N. H., read a paper on Eight-wheeled Cars, advocating their use on street railroads.

A paper on Street Railway Mutual Fire Insurance, by John Maguire, of Mobile, Ala., was read by William J. Richardson, of Brooklyn. The plan suggested by Mr. Maguire was referred to a Committee composed of Messrs. Woodward, of Rochester; Frazier, of Memphis; Moss, of Sandusky, O.; Swain, of New York, and Crossin, of London, Canada.

Mr. C. A. Vandepoele, of the Vandepoele Electric Company, of Chicago, addressed the convention on the subject of Electric Railroads, stating it as his belief that electricity would finally supersede every other motor on street railroads. The subject was discussed at length during the afternoon.

Elias E. Ries read a paper on A New Method of Increasing the Tractive Adhesion of Driving-wheels.

The following officers were elected for the ensuing year: President, Charles B. Holmes, Chicago; First Vice-President, Julius E. Rugg, Boston; Second Vice-President, Dudley R. Frazier, Memphis, Tenn; Third Vice-President, Charles B. Clegg, Dayton, O.; Secretary and Treasurer, William J. Richardson, Brooklyn, N. Y.; Executive Committee, Thomas W. Ackley, Philadelphia; Winfield Smith, Milwaukee; Daniel F. Lewis, Brooklyn, N. Y.; Charles Green, St. Louis, and Edward G. Mosher, Augusta, Ga.

The next convention will meet in Washington, on the third Wednesday of October, 1888.

Engineers' Club of Philadelphia.

AT the last spring meeting of this Club, on June 18, the following new members were elected:

Active Members: W. H. Frances, P. Doyle, John C. des Granges and Francis W. Whiting.

Associate Members: Robert Neilson and Horace B. Powell.

At the same meeting, Mr. John L. Gill, Jr., presented a description of a New System of Screw Threads which he had arranged, and asked that a committee be appointed to examine and report upon the same. The President appointed the following committee: Henry G. Morris, Chairman; John T. Boyd, Professor L. M. Haupt, Washington Jones and M. R. Muckle, Jr.

THE first fall meeting was held at the Club's House in Philadelphia, October 1, Past-President Washington Jones in the chair; 30 members and 4 visitors present.

Mr. J. M. Cameron, introduced by Mr. Henry G. Morris, described the Carnell Air Injector.

This machine is intended to supply air to the furnaces of steam boilers of all classes. Steam is taken from top of boiler and carried through the combustion chamber, where it is heated to about 900° Fahr., then to a distributing apparatus discharging under the grate. The steam, heated to the condition of a gas, takes with it the necessary air for combustion. It is claimed that the heat to which the steam is raised, in connection with a reduction of pressure to 20 lbs. per square inch, increases the relative volume to 1,800, which would be eight times more effective than saturated steam. The heat taken from combustion chamber is given out to the air entering the furnace. Tests are said to have shown an increased boiler power of 28 to 100 per cent., with a proportionate saving in fuel of 2 per cent. above that obtained by natural draft.

Mr, Henry G. Morris exhibited and described a working model of a Traveler to Carry Wires, Ropes, etc., through Conduits, which he had devised.

The apparatus consists of two parts, one placed ahead of the other, and each provided with spring claws, which will slide ahead in the conduit, but will take hold of the sides and prevent any backward motion. The parts are operated by two cords working on a system of pulleys, so that, by the alternate pulling of the cords, the whole apparatus will move ahead of the operator through the conduit. That is to say, pulling one cord will drag the rear piece up to the front piece, and pulling the other cord will send the front piece a distance ahead, each part, with the attached pulleys, holding firmly to the sides while the other part is being moved.

Prof. L. M. Haupt made some remarks upon his Experiments with Current Deflectors at Five-Mile Bar, and showed how urgently the City and river interests required a channel across it. He then suggested a plan whereby he proposed to create a channel sufficient to meet the demands of commerce, upon the following principles:

1. If the *bottom velocity* of a stream be increased to the limit by the character of the material forming its bed, it will scour; if diminished, it will deposit.

2. If the *momentum* of a stream be suddenly arrested by an obstruction placed in its path, a reaction will be produced, its head will be increased, and the bottom will be scoured out.

3. If the *volume* of a stream be partially deflected by a trailing wall, from one side of a cross-over bar to the opposite side, the current over the bar will be quickened and the crest lowered above the line of the works.

4. If the *form* of the cross-section of a stream be modified by cutting at one point and filling at another point of the same section so that the area is not changed, other things being equal, the discharge will not be materially affected, and the part so deepened will remain open.

5. If a stream be compressed laterally into a smaller section, ts velocity head near the banks will be increased, while that at the center will be diminished, and consequently the channel will be bifurcated and the deepest water be found near shore.

If, by the application of these laws of flowing water, a channel, sufficiently wide and deep for navigation, be cut across a bar, it will be self-sustaining, and cost much less than if the entire bar were disturbed by the usual lateral dikes or by dredging.

The Secretary announced the death, since the summer adjournment, of Mr. Frank Maddock, Active Member of the Club.

American Society of Civil Engineers.

A REGULAR meeting was held at the Society's House in New York, October 5, which was devoted entirely to business.

Mr. J. P. Davis presented a resolution providing for the appointment of a Committee to consider and report an amendment to the Constitution relative to the mode of electing members.

This resolution was discussed by Messrs. Davis, Wellington, Dorsey, North, Bogart, O'Rourke, Croes and Brinckerhoff, and was finally passed; the President appointed on the Committee Messrs. Davis, Wellington and Paine.

A report was received from the Committee appointed at the last convention to consider and report on the advisability of creating the grade of Student in the Society. After discussion by Messrs. Croes, Paine, North, Davis, Bogart and Wellington, it was resolved that the report be accepted and printed for distribution to Members, and that the Committee be continued, with a request that a further report be presented at the meeting of the Society on the first Wednesday in November. The report will be found below.

The following elections were announced:

Members.—Henry St. Leger Coppee, Vicksburg, Miss.; Henry Clay Derrick, Halifax Court-House, Va.; Joseph Norton Greene, Willimantic, Conn.; Edward Buckingham Guthrie (elected Associate September 3, 1884), Buffalo, N. Y.; Charles Edward Hewitt, Trenton, N. J.; Wynkoop Kiersted, Falls City, Neb.; James Imbrie Miller, Tarrytown, N. Y.; Palmer Chamberlaine Recketts, Rochester, N. Y.; Granville Wheaton Shaw, Louisville, Ky.

Associate.—Gratz Mordecai, Washington, D. C.

A meeting was held at the Society's House in New York, October 19. The first paper presented, through Mr. E. P. North, was on Brick-Making in Sinaloa, Mexico, by Juan José Avela.

The Secretary then read papers on Cement Tests, by Emil Kuichling and E. B. Noyes. These were generally discussed by members present.

A circular issued by the Secretary, in accordance with the action noted above, refers to the resolution adopted at the meeting at the Hotel Kaaterskill in July last, on the question

of creating the grade of "Students" of the Society, and presents the report of the special Committee to which that resolution was referred. This report, which is signed by Messrs. Robert E. McMath, Robert H. Thurston, W. H. Paine and Robert Moore, is in substance as follows:

"In considering the advisability of creating this new grade of membership, we have taken into full account the only objection that has been raised to such action; that it would lower the standard of the Society. If there be danger of such result, then your Committee would certainly report that the proposed action is not advisable. If membership of the Society is to remain as now established, then to add a lower grade would, in a certain sense, lower the average of the Society and so afford some ground for the objection. If, on the other hand, the creation of a new grade is made the occasion of an advance in the standard of qualification for the higher grades, then the spirit of the objection is an argument for the proposed action. Another consideration influences your Committee, which is, that we find scant room for a grade of students below the requirements for the present class of Junior. We therefore say, decidedly, that if the Society is unwilling to raise the standard of qualification required for membership in grades now established, then it is inexpedient and not advisable to create the proposed grade of students.

"But if the Society is ready to raise the standard for all grades, then we say the creation of the proposed grade of students is expedient and advisable.

"To test the disposition of the Society, and with confidence that it is ready for a step in advance, we report in favor of the adoption of the accompanying amendments and resolution:

AMENDMENTS TO THE CONSTITUTION.

"ARTICLE XVI. The active members of the Society shall be divided into three classes, to be styled respectively Members, Associate Members and Associates; and each person, when duly elected and qualified, shall receive a certificate of Membership indicative of the class to which he belongs.

"Associate Members shall have all the rights and privileges of Members excepting the right to hold office or to vote upon admission to membership. Associates shall have all the rights and privileges of Members excepting the right to hold office or to vote.

"There shall also be a preparatory grade, to be designated Students of the Society, who shall have the right to attend all meetings not strictly devoted to business, and to use the library and rooms of the Society under such regulations as the Board of Direction may adopt. They shall have by right the *Transactions* of the Society and the privilege of presenting papers and written discussions.

"Members of the class previously styled Juniors, shall, after March 7, 1888, be classed as Associate Members.

"ARTICLE XVII. A Member shall be a Civil, Military, Mining or Mechanical Engineer, not less than 30 years of age, who has been in active practice as such for at least ten years or has graduated at a school of engineering after a full course of study and been in practice seven years, and who continues in actual practice at the time of application for membership, and who has had responsible charge of work as Chief, Resident or Superintending Engineer for at least two years, not as a skillful workman merely, but as one qualified to design as well as to direct engineering works.

"An Associate Member shall be one over 24 years, who has had actual practice in some of the branches of Civil, Military, Mining or Mechanical Engineering for at least five years; or, if a graduate of a school of engineering after a full course of study, who has practiced at least two years.

"An Associate shall be one over 25 years of age, who is a manager of a railroad, canal or other public work; a geologist, chemist or mathematician; a proprietor or manager of a mine or metallurgical works; an architect or a manufacturer; or one who, from his scientific acquirements or practical experience, has attained eminence in his special pursuit, qualifying him to co-operate with engineers in the advancement of professional knowledge; but shall not himself be practicing as an engineer.

"A Student shall be one not less than 18 years of age, who is engaged in the study of engineering with the intent to become an engineer, and who has pursued that study at a technical school not less than one year, or who shall have been engaged in the study and practice of engineering under a competent engineer for not less than two years. A Student shall not remain in that grade for more than seven years; if not elected to a higher grade his connection with the Society shall terminate at the end of seven years.

"ARTICLE XVIII. Insert after 'Society,' at end of first line of printed copy, the words, 'except to the grade of Student.'

"Also, ARTICLE XVIII. (Insert at end of first paragraph) 'Nominations for Students shall be made out as for other grades, but the endorsement may be signed by a Member, Associate Member or Associate, and but one such signature will be required. Such nominations shall follow the usual course of procedure for other grades except submission to a letter ballot. The Board of Direction shall elect or reject the applicant.'

"The resolution fixing entrance fee and annual dues for Associate Members and Students is as follows:

"*Resolved*: In the event of the Society adopting amendments to the Constitution creating the grades of Associate Member and Students of the Society, that the entrance fee and annual dues of Associate Members shall be the same as established for Associates; for Students no entrance fee shall be required, and the annual dues shall be, for resident Students, $10 and for non-resident Students, $6 per annum."

A supplement to the report is added by the Committee giving its reasons in detail for the proposed changes. Mr. Frederick Brooks, a member of the Committee, made a minority report presenting amendments differing from those given by the majority in some details, and retaining the name of Junior for the grade called Associate by the Committee.

Master Car-Builders' Association.

AT a recent meeting of the Executive Committee in New York, it was announced that on the question of adopting the Janney type of car-coupler as the standard of the Association, the letter-ballot stood: For, 474; against, 194. Over two-thirds of the vote being in favor of the standard, it is declared adopted.

The other standards submitted to letter-ballot at the same time (Draft-rigging for non-automatic couplers; Axle and journal-box for cars of 60,000 lbs. capacity; Sizes of lumber for freight cars) failed to receive a two-thirds vote and were not adopted.

The resignation of the Secretary was considered, but the Committee declined to accept it.

The following resolution was adopted at this meeting:

"*Resolved*, That a sub-committee of five be appointed to critically examine the different forms of couplers coming within the Master Car-Builders' type, and report the result of their examination to the Executive Committee on the second Thursday in January, 1888, for their further action."

Messrs. Wall, Wade, Lentz, Cloud and Forney were appointed such Committee.

PERSONALS.

Mr. H. L. Cooper has resigned his position as Superintendent of Equipment of the Lake Erie & Western Railroad.

Mr. M. Reedy has been appointed Roadmaster of the St. Louis, Vandalia & Terre Haute Railroad.

Commander Edgar C. Merriman, U. S. N., has been detailed as Equipment Officer of the Boston Navy Yard,

Mr. P. Reilly has been appointed Superintendent of Equipment of the Lake Erie & Western Railroad, with office at Lima, O., in place of H. L. Cooper, resigned.

Mr. B. C. Bosworth has been appointed Superintendent of Machinery of the Colo Midland Railroad, with office at Colorado Springs, Col., succeeding William Fuller, resigned.

Colonel Henry G. Prout has retired from the firm of Atkin & Prout, printers, and will hereafter devote his whole time to his duties as Managing Editor of the *Railroad Gazette*.

Mr. William Torrence has been appointed Master Mechanic of the Ohio Valley Railroad, with headquarters at De Koven, Ky.

Mr. W. H. Brinckerhoff, M. Am. Soc. C. E. has accepted a position on the editorial staff of the *Engineering and Building Record* (late the *Sanitary Engineer*), of New York.

Assistant Naval Constructor John B. Hoover, U. S. N., has been ordered to special duty in connection with the new cruisers now building at Cramp's yard in Philadelphia.

Mr. Samuel Thomas has resigned his position as President of the Thomas Iron Company, after nearly 35 years' service, on account of continued ill health.

Mr. David L. Barnes has resigned as Chief Draftsman of the Rhode Island Locomotive Works and will open an office as consulting engineer.

Mr. Arthur C. Moore has charge of the surveys and plans for new water-works for the town of Brookfield, Mass. He has just completed plans for a new reservoir for the Southbridge water-works.

Mr. Edwin Thacher, Chief Engineer of the Keystone Bridge Company, has accepted the position of Chief Engineer to the Decatur Bridge Company, recently organized at Decatur, Ala., and will proceed to his new field shortly.

Mr. A. Gordon Jones has been appointed Superintendent of the Little Rock & Memphis Railroad, with office at Memphis, Tenn. He was formerly on the Baltimore & Ohio Railroad.

Mr. S. Wright Dunning, formerly Editor of the *Railroad Gazette*, sailed from New York, September 27, on an extended trip to Europe. He is accompanied by Mrs. Dunning, and purposes spending at least two years abroad.

Mr. C. F. Resseguie has been appointed Superintendent of the Idaho Division of the Union Pacific, with office at Pocatello, Idaho. He has been for 11 years on the Chicago, Burlington & Quincy, and was recently Superintendent of the Illinois lines of that road.

Mr. J. C. Monroe has been appointed Master Mechanic of Kansas City, Memphis & Birmingham Railroad, with office in Memphis, Tenn. He was recently on the Missouri Pacific at Palestine, Texas.

Mr. Robert Garrett has retired from the office of President of the Baltimore & Ohio Railroad Company in consequence of recent charges in the control of that company. Mr. Garrett is not at present in good health, and has gone to Mexico on a long trip. Reports have been circulated that his mind is affected, but they do not appear to rest on any very reliable basis.

Mr. E. H. Walker, for many years Statistician of the New York Produce Exchange, has joined the editorial staff of *Bradstreet's*, the well-known commerical and financial newspaper published in New York, to which he will give his exclusive services. Mr. Walker is perhaps the best informed man now in the country on the statistics of grain, flour, provisions, live stock and kindred lines.

Mr. John D. Kernan, Chairman of the Board of Railroad Commissioners of the State of New York, has resigned his office, to date from November 14. Mr. Kernan expects to resume the practice of law in New York City. He has been active in the work of the New York State Commission, especially in connection with the drafting of amendments to the general railroad laws and Legislation for the regulation of railroads and the protection of the traveling public and railroad employés. The accurate compilation of the railroad law of the State, contained in each annual report of the Board and prepared under his supervision, is highly spoken of by lawyers. The weight given to his recommendations as to National railroad legislation by the Cullom Committee of the United States Senate led to the general belief that he would be appointed an Inter-State Commerce Commissioner last spring.

NOTES AND NEWS.

A Mountain Tramway.—The Gilpin Tramway Company is building a road of 2 ft. gauge to carry ore from mines in the mountains near Central City, Col., to the mills at Blackhawk. The line, which is more than half finished, is 10 miles long, and is nearly all on a grade of 3½ per cent., or 185 ft. to the mile. It will be equipped with 2 locomotives of the Shay pattern, made at Lima, O., and 100 ore cars.

Electric Lighting of Cars in Russia.—The Russian Minister of Railroads has appointed a commission to select a method of lighting railroad cars with electricity, and all the principal companies will hereafter be compelled to use the light on passenger trains. The South Russian Railroad has for some time used electric light on all its fast trains from Odessa to Kieff, and the Czar's special trains have been so lighted for a long time.

Proposed New Russian Canal.—The Dwina and the Dnieper are to be joined by a new canal which will connect the River Loutchesa, flowing into the Dwina near Vitebsk, and the River Ochitcha, flowing into the Dnieper. This project also entails deepening and improving the means of navigation on the Dwina and on the Dnieper, which will cost 2,000,000 roubles, while the cost of the construction of the canal is estimated at 8,000,000 roubles ($3,600,000).

The French Exposition of 1889.—Official notice has been issued that the Committee of Class 61 (which includes material of all kinds for railroads and tramway-, cars, engines, etc.) has been organized. Its first work is to determine how much space will be needed for exhibits of this class, and for this purpose those who intend to exhibit are urgently requested to notify the Committee at the earliest possible date of the amount of space they will require and of the nature and extent of their exhibits.

Baltimore & Ohio Employes' Relief Association.—The August sheet of this Association shows payment of benefits as follows:

	Number.	Amount.
Accidental deaths	3	$4,500
Accidental injuries	357	4,958
Natural deaths	15	7,750
Sickness	608	8,798
Physicians' bills	258	1,453
Total	1,241	$27,459

From the foundation of the Association in 1880 it has paid out in all $1,482,301 in benefits.

The Vanderbilt Building.—The new building in New York, given by Mr. Cornelius Vanderbilt for the benefit of the employés of the New York Central & Hudson River road, was formally opened October 3, when speeches were made by Mr. Vanderbilt, Bishop Potter, Mr. Chauncey M. Depew and others to a large number of invited guests.

The building will be under the charge of the Young Men's Christian Association. It has on the first floor a library containing 6,000 volumes, a reading room, social room and bathrooms. On the second floor is a large hall for meetings, etc. In the third floor is the recreation room, comfortably fitted up with lounges. Here the men can get hot coffee free of charge, while all the cooking appliances necessary for a restaurant are on hand. In the top floor is a large room fitted up with brass bedsteads for the use of railroad men compelled to stay in the city over night. Everything is most handsome and complete.

Railroads in Colombia.—Mr. E. W. P. Smith, Consul at Carthagena, Colombia, writes to the State Department: "A Franco-Belgian syndicate of capitalists has just secured a most important concession from this Government for the construction of two grand trunk lines of railroads between a port on the Atlantic and one on the Pacific to Bogota. The Government, in addition to a guarantee of 7 per cent. on a capital of $80,000,000, gives the company large land grants, and exempts from contribution and import duties all material and supplies that may be introduced into the country by the company. This enterprise could have been secured by American capitalists had they sent proper representatives out here to obtain it.

"An enterprising American has obtained the privilege of constructing a tramway in this city, and has gone home to obtain the necessary outfit for its mimediate construction."

The Cairo Bridge.—The bridge over the Ohio River at Cairo, Ill., for the Illinois Central Railroad will have 12 spans, two of 518½ ft. each, center to center of piers; seven of 400 ft. each and three of 250 ft. each, making the total length 4,670 ft.

The approaches will be wooden trestle, to be filled with earth by train after the bridge is open for traffic.

The clearance line of the superstructure is 53 ft. above extreme high water. High water mark is 52.17 ft. above extreme low water. The foundations in the river will be at least 75 ft. below low water, so that the total height of piers will be about 180 ft.

The foundations in the river will be sunk by the plenum pneumatic process. The caisson will be surmounted by a crib filled with concrete, and the total height of the caisson and crib will be 50 ft. The masonry will be built of stone from Bedford, Ind., except the up-stream nose stone, between high and low water, which will be of granite. The superstructure will be entirely of steel, except pedestal castings and some unimportant parts. The plans are now prepared in detail, and the work is well under way.

The entire work will be completed by the close of 1889, about 2½ years from the date of commencing the work. The entire cost is not expected to exceed $2,500,000. The bridge is single track.

The plans have been made by and the work is under the charge of Messrs. Morison & Corthell, with Mr. Alfred Noble as Resident Engineer.

The Union Bridge Co., of New York, have the contract for nearly all the work on the main bridge.

Railroads in Hayti.—Mr. John E. W. Thompson, Consul-General to Hayti, writes to the State Department as follows: "A law sanctioning the contract for the building of a railroad from the city of Gonaïves to Gros Morne, a distance of about 24 miles, with eventual termination at Port de Paix, was published in the *Moniteur* of the date August 19, 1886. This contract has been made with a French firm, who some years back sent engineers exploring into that part of the country, and who evidently found the condition particularly rich and profitable for the scheme, because ever since they have been striving to get the concession, and the only subvention given by the Government consists in the wood found in a parallel of 10 kilometers to the right, and 10 to the left of the line on the public ground of the State. It is said that the above named country abounds in forests of the finest quality of mahogany and logwood, and these valuable products, owing to there being no mode of transporting the same to the sea-ports, could not be utilized for exportation. The line is to be entirely finished at the expiration of 28 months; also the rails are to be laid to the wharves, in order to communicate directly with vessels loading.

"Such an enterprise embodies results of more or less significance. If successful, it will be the means of causing similar lines to be laid at available points and thus opening up anew the exportation of articles now difficult to obtain. Brazil-wood and other valuable woods which have a marked value are now unavailable for want of roads and means of transportation to the seaboard cities."

Blast Furnaces of the United States.—The *American Manufacturer* says: "Our usual monthly statement of the condition of the blast furnaces of the United States, on October 1, in a condensed form, makes the following showing:

	In blast.		Out of blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	15,171	104	11,420
Anthracite	122	36,044	79	19,234
Bituminous	151	93,423	61	25,505
Total	346	144,638	244	56,159

"There has been a reduction during the month of total number of furnaces in blast of 6. There are 6 less charcoal furnaces blowing, 8 less anthracite and 8 more bituminous.

"As compared with a year ago, the condition of the furnaces in blast is as follows:

	Oct. 1, 1887.		Oct. 1, 1886.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	15,171	66	11,105
Anthracite	122	36,044	121	34,091
Bituminous	151	93,423	132	76,270
Total	346	144,638	319	121,476

"The most notable feature of the report for this month is the large number of coke furnaces in blast, 151, with a weekly capacity of 93,423 tons. This is the largest number of coke or bituminous furnaces and capacity ever reported as blowing, the nearest approach to it was April 1, 1887, when the same number of furnaces was reported as in blast, but the reported capacity was but 86,709 tons."

Electro-Magnetic Machine Tools.—The first successful examples of electric machine tools are the electro-magnetic machines introduced by Mr. John McMillan, Sr., into the practical work of his shipyard, at Dumbarton, Scotland, from which, on May 19, 1887, was launched the screw steamer *Albania*, having a portion of the rivet holes in her shell drilled by these machines. After a very small amount of practice, the men working the machines drilled the $\frac{7}{8}$-in. holes in the shell with great rapidity, doing the work at the rate of one hole every 69 seconds, inclusive of the time occupied in altering the position of the machines by means of differential pulley-blocks, which were not conveniently arranged as slings for this purpose. Repeated trials of these drilling machines have also shown that, when using electrical energy in both holding-on magnets and motor amounting to about $\frac{3}{4}$ H. P., machines have drilled holes of 1 in. diameter through $1\frac{1}{2}$ in. thickness of solid wrought-iron, or through $1\frac{5}{8}$ in. of mild steel in two plates of $\frac{13}{16}$ in. each, taking exactly $1\frac{3}{4}$ minutes for each hole. Another machine, which has magnets of less holding power, when using only about 0.6 H. P. of electrical energy, took the same time to drill holes of $\frac{11}{16}$ in. diameter through wrought-iron of $\frac{13}{16}$ in. thickness. As regards speed of drilling, it is believed that these results are equal to any obtained by machines using much greater power. With a hammer using an electro-motor giving out one half brake H. P., from 100 to 150 blows per minute have been obtained, with a force of impact equal to about 180 foot-pounds per blow, as nearly as could be ascertained. This is much greater than the force of blow given by hand hammers weighing 6 pounds and striking as heavily as is possible in staving up. At the works of Messrs. Immisch & Co., in March last, this riveter was seen closing 1-in. rivets in 10 seconds each. The electro-motors used in the machines constructed for Mr. McMillan, with which these results have been obtained, were of Messrs. Immisch's design and manufacture. After seeing the machines at work in Messrs. McMillan's yard, Messrs. William Denny & Brothers constructed an electrical drilling machine having a modification of the traversing frame, but without holding-on magnets, and applied this machine to drilling the rivet holes in the butt joints of a large steamer.

Domestic Motive Power by Atmospheric Exhaustion.—M. A. Tesca, in the *Bulletin de la Société d'Encouragement*, says that the Society for the Distribution of Power in Dwelling Houses has established a system of domestic motive-power in the Rue Beaubourg, one of the most populous districts in Paris, supplying power in small quantities to work the tools or machines employed in small industries. M. Petit, the inventor, assisted by M. Boudenot, erected at first a powerful steam-engine of 75 H. P., with a boiler, which was employed to work a large air-pump, placed behind the steam-cylinder for the purpose of exhausting the air from an underground conduit into the atmosphere. From this main conduit, placed for the most part in the sewers, small pipes or tubes were branched into the blocks of houses, ending in rising columns, analogous to those employed for the distribution of gas in the interior of houses.

The vacuum thus maintained in the main conduit and its branches, serves to drive the small motors erected in each work-room, by the rush of the air of the rooms through the motors into the pipes, after having acted by its pressure on the pistons of the machines. Whatever the number of open branches, that is to say, of little motors in action, the vacuum is maintained in the conduit, supposing, of course, that the duty of the air-pump is equal to the volume of external air entering the conduit from the various branches. For this purpose, the vacuum-gauge is provided with alarms to announce excess of pressure or of vacuum, as the case may be. Uniformity of pressure can be easily maintained by the attendant; and thus it is that, whilst the engine may work slowly at certain hours of the day, it may work at double the speed when the demand for power is augmented. Each motor is fitted with a meter, by which the consumption is correctly gauged.

The installation in the Rue Beaubourg commenced operations in January, 1885; and May, 1886, the power was entirely utilized in driving 70 small motors, in as many workshops, of a power of from 40 foot-pounds to 290 foot-pounds, on a length of about 5,000 ft. of passage-way in the Rue Beaubourg and the adjoining streets.

The new exhausting steam engines and pumps are in course of erection alongside the first one, and the complete installation will consist of 3 exhausting steam engines and pumps of 75 H. P. each, or together 225 H. P.; 2 steam-boilers; a system of passage-ways 6,600 ft. long, and about 200 small motors on the different floors of a block, or separately in the different houses of the quarter.

A Petroleum Tank Steamer.—We recently noticed the launch from the Low Walker ship-building yard of Messrs. Sir W. G. Armstrong, Mitchell & Co., of the steamer *Ville de Calais*, which has been specially built for the carriage of crude petroleum in bulk, and which is, we believe, the first steamer of the kind that has ever been specially constructed for this purpose. The *Ville de Calais* is built of steel to the highest class Veritas, and is capable of carrying 2,400 tons dead weight, on less than 18 ft. draft. She is subdivided by a longitudinal and athwartship bulkhead into numerous cells or compartments, each of which has its own expansion chamber, which latter also forms a receptacle for the gases which are evolved from the cargo. These arrangements in this vessel are of a very special description—petroleum in its crude state being much more volatile than refined; for this reason, also, the general construction and workmanship of the hull had to be treated more like boiler-work than ordinary ship-building; and before launching, each compartment was tested with water, having a head pressure considerably in excess of what would be sustained in ordinary working. There is a very complete installation of pumps on the Worthington system, both for discharging the cargo and equalizing at will the amount of oil contained in the various compartments. The machinery is on the triple-expansion system, by the Wallsend Slipway & Engineering Company, and during her trial on Thursday last worked with perfect smoothness and without the slightest hitch. The vessel was fully laden with water to the contract draft, and obtained a speed of 10 knots. On Saturday, she sailed to Calais, where she has since arrived, all well, after a

good run. The whole of the vessel's arrangements are of the most complete description, including a full electric-light installation by Messrs. Clarke, Chapman, Parsons & Co. Sir W. G. Armstrong, Mitchell & Co. have given the construction of petroleum steamers their special attention, and the *Ville de Calais* is the third tank steamer delivered by them this year, the previous vessels being the *Minister Maybach* of 3,300 tons d. w., and the *Hans und Kurt* of 2,800 tons d. w.; whilst a fourth, named the *Willkommen* of 4,000 tons d. w., will take her trial trip this week; and the same builders have yet another vessel in hand in an early stage of construction.—*The London Engineer.*

The Best Way of Destroying a Railroad.—A knowledge of the art of building railroads is certainly of more value to a country than that of the best means of destroying them; but at this particular time the destruction seemed necessary, and the time may again come when such work will be necessary. Lest the most effectual and expeditious method of destroying railroad tracks should become one of the lost arts, I will here give a few rules for the guidance of officers who may in future be charged with this important duty. It should be remembered that these rules are the result of long experience and close observation. A detail of men to do the work should be made on the evening before operations are to commence. The number to be detailed being, of course, dependent upon the amount of work to be done, I estimate that 1,000 men can easily destroy about 5 miles of track per day, and do it thoroughly. * * * * Your detail should be divided into three sections of about equal numbers. I will suppose the detail to consist of 3,000 men. The first thing to be done is to reverse the relative positions of the ties and iron rails, placing the ties up and the rails under them. To do this, Section No. 1, consisting of 1,000 men, is distributed along one side of the track, one man at the end of each tie. At a given signal each man seizes a tie, lifts it gently till it assumes a vertical position, and then at another signal pushes it forward so that when it falls the ties will be over the rails. Then each man loosens his tie from the rail. This done, Section No. 1 moves forward to another portion of the road, and Section No. 2 advances and is distributed along the portion of the road recently occupied by Section No. 1. The duty of the second section is to collect the ties, place them in piles of about 30 ties each—place the rails on top of these piles, the center of each rail being over the center of the pile, and then set fire to the ties. Section No. 2 then follows No. 1. As soon as the rails are sufficiently heated, Section No. 3 takes the place of No. 2, and upon this devolves the most important duty, viz., the effectual destruction of the rail. This section should be in command of an efficient officer, who will see that the work is not slighted. Unless closely watched, soldiers will content themselves with simply bending the rails around trees. This should never be permitted. A rail which is simply bent can easily be restored to its original shape. No rail should be regarded as properly treated till it has assumed the shape of a doughnut; it must not only be bent but twisted. To do the twisting, Poe's railroad hooks are necessary, for it has been found that the soldiers will not seize the hot iron bare-handed. This, however, is the only thing looking toward the destruction of property which I ever knew a man in Sherman's army to decline doing. With Poe's hooks a double twist can be given to a rail which precludes all hope of restoring it to its former shape except by re-casting.—*General H. W. Slocum, in the Century for October.*

Coal and Petroleum in the Argentine Republic.—Consul E. L. Baker writes to the State Department from Buenos Ayres: "The question of coal deposits in the Argentine Republic, about which there has, in the past, been so much doubt and uncertainty, is gradually approaching an affirmative solution. In my last annual report I referred to the discoveries made by Colonel Oloscoago, in the southern portion of the province of Mendoza; as also the discoveries announced by an American miner in the province of San Juan. We now have information that 'coal of first-class quality and abundant' has been discovered at two different points, one 40 leagues and the other 50 leagues south of San Rafael, a small town in the province of Mendoza. Likewise, Prof. L. Brackenbush, of the University of Cordoba, who has been making scientific researches on the estate of Sr. Igarzabal, near Paganso, in the province of Rioja, announces to the public that 'coal is there, rich and abundant, and only 30 kilometers from the Colorados Railway station on the Chilceto & Dear-Funes Railway line.' A plan of the deposits has been drawn up with a view to their exploration. So I suppose the conundrum of coal or no coal may now be considered as fully answered in the affirmative.

"I may add here, that a company has lately been formed in this city for working the petroleum deposits, heretofore announced by me to have been discovered near the city of Mendoza. We now have intelligence that at a depth of 120 meters the deposit was reached, and that a steady steam of pure petroleum comes to the surface. The news has caused some stir here, in view of the great and constant demand all over the Argentine Republic for kerosene oil, the bulk of which now comes from the United States. Owing, however, to the distance from the River Plate at which this Argentine petroleum is found, and the expense of transportation, I doubt if it will be able to compete in price with the American article, unless the Argentine Government puts on a prohibitive tariff."

Railroads in the Argentine Republic.—Consul E. L. Baker, at Buenos Ayres, in his annual report to the State Department for 1880, says: "The work of railroad construction has been prosecuted with more than usual activity during the past year.

"The extension of the Central-Northern road is now completed a distance of 270 kilometers beyond Tucuman, and most of the work is ready for the superstructure as far as Salta. One hundred kilometers of road have likewise been completed between Rosario de la Frontera and Metan. The work between Chilcas and the Rio Passagè is in progress, and the whole line will be pushed during the coming year, as also the branch from Dear-Funes to Chilceto, a distance of 415 kilometers.

"All the accessory works of the branch of the Northern Central to Santiago del Estero have been finished, and also of the branch to Chumbicha, 176 kilometers, and both lines have been opened to the public sarvice.

"The road from Buenos Ayres to Rosario, a distance of 305 kilometers, finished at the date of my last annual report, has been running regularly during the last year, thus reducing the time between the two places to seven hours. It is now being extended on to Sunchales, 45 kilometers, and will soon be completed to that point.

"A second road, projected in the interest of the Buenos Ayres & Pacific road, is now under construction from here to Mercedes, in this province, where it is to connect with the said Pacific road, now completed as far as Mercedes, in the province of San Luis, a distance of 336 kilometers. It is now being further pushed on to Orellanos, 355 kilometers, to which place it will be finished in a few months. From Mendoza, westward, the last link in the Andine road is now under contract.

"Various other roads have been projected, and for some of these concessions have been obtained from the Government; among these is a railway from Bahia Blanca directly across the Andes by a new pass to Chili, and another from Buenos Ayres also across the Andes to Chili by a southern pass.

"As showing the progress which railroad construction has been making in the Argentine Republic, I may say that in October, 1880, the total number of kilometers was 2,318, of which 810 belonged to the National Government, 348 to the Provincial Government of Buenos Ayres, and 1,104 were in private hands. There are now 6,152 kilometers in the Republic, of which 1,877 belong to the Nation, 1,104 to the Provincial Governments and 3,161 to private companies; a gain of about 3,834 kilometers in a little over five years."

New York Harbor Improvements.—Lieutenant-Colonel Walter McFarland, U. S. Engineers, has submitted to the War Department his annual report upon the work of improvement of New York Harbor. The report states that the survey of Gedney's Channel, finished on June 21, showed that the channel has maintained the increased depth which it had received, and leads to the belief that the still greater depth which the act of Congress calls for may be equally maintained when once secured.

All the work of improving Gedney's Channel and the main ship channel is now in the hands of one firm, and the indications are that the work of deepening Gedney's Channel will be finished this year. The dredges will then be set at work on the main ship channel, the deepening of which is to be finished by December 1, 1888. Under the present agreements, 700,000 cubic yards of material will be removed from Gedney's Channel and 1,500,000 from the ship channel. This is said to be not much more than one-half the amount of material that must be removed in order to secure a depth of 30 ft. at mean low water, with a width of 1,000 ft., and the removal of the remainder will cost $540,000. Colonel McFarland makes an earnest protest against the injury now being inflicted on the harbor by dumping into it the dredgings of the docks and slips and ashes and cinders from steam vessels, and instances cases where lumps and shoals have been formed in this way.

The sum available on July 1 for the improvement of New York Harbor was $742,293, and the amount that can be profitably expended during the next fiscal year is $540,000, unless

it should become necessary to resort to contraction works, which would cost between $4,000,000 and $5,000,000.

In the River and Harbor bill of August, 1886, an appropriation of $112,500 was made for continuing the work at Hell Gate. The amount was too small to admit of working the drill-scow on the small reefs and continuing work on Flood Rock at the same time, and it was determined to apply it entirely to the latter purpose by increasing the wid h of the new middle channel by dredging a cut along its easterly margin to the full depth of 26 ft. Work was begun with two machines in November and continued until April 15, after which time one machine only was used, working night and day.

The latter method of working has not, however, given as good results as working two machines by daylight only, the progress having fallen from 113 tons per machine per day of 12 hours to 59 tons. This decline in the rate of progress is partly to be attributed to the accumulation on the reef, after it has been worked over a considerable time, of fine material which is too small to remain in the grapple while it is being hoisted through the swift current. It has not been thought practicable, however, to use an ordinary dredging bucket to pick up this material, because scattered through it are occasional large masses which would soon destroy the bucket. The total amount of material removed during the fiscal year was 34,956 tons, leaving about 230,000 tons yet to be removed.

The amount that can be profitably expended in the removal of obstructions in the East River and Hell Gate during the next fiscal year is $500,000, to be applied chiefly to the removal of Flood Rock and to continuing operations with the steam drill scow on other obstructions.

Well-Water.—The great majority of the people in this country obtain their drinking water from the moving sheet of water which lies at a greater or less depth beneath the surface of the earth, and for this purpose they use wells.

The questions as to how far, and under what circumstances, well-water may be dangerously contaminated, and how such contamination may be best recognized when present, or be foreseen and guarded against, are therefore of constant interest. The *Journal* of the Chemical Society for June of this year, contains a paper by Robert Warrington, entitled "A Contribution to the Study of Well-Water," which is of more than ordinary value and interest. In this paper are given the results of a continuous and systematic examination of the well-waters of Rothampsted, England, and of the connection between the composition of rain, drainage and deep-well waters. Taking a series of observations for several years it was found that the rain contained, in a million parts, an average of two parts of chlorine, 0.67 part of combined nitrogen, and 2.52 parts of sulphuric acid. By drainage through 5 ft. of bare soil the quantity of chlorine is not increased, but the combined nitrogen is increased about nine times by oxidation of the organic matter in the soil. The production of nitrates occurs chiefly in the summer months, and the first considerable drainage which occurs after summer will contain the greatest proportion of the nitrates.

Nitrates being assimilated by plants are generally absent in drainage from land bearing an actively growing crop. The proportion of chlorine in the purest wells at Harpenden is about 11 per million, and it varies very little. Wells in soil much contaminated by sewage may show the commencement of a rise in the chlorides one or two months after the active autumn drainage begins, and two months before the water-level in the well begins to rise. Wells little liable to contamination show a rise in chlorides later in the season. When soil has been long contaminated by sewage, and then fresh contamination ceases for a number of years, the proportion of chlorides in the well-water may be considerably higher than normal, but it will remain nearly unaltered through the drainage season.

In contaminated well waters the proportion of nitrates and chlorides increases at first at an equal rate, but if active drainage continues the proportion of nitrates greatly increases. The sewage of a poorly-fed population gives a high proportion of chlorides to nitrates, while stable sewage causes the reverse. The chloride contamination is more permanent than that by nitrates. The probable average proportion of nitrogen as nitrates in drainage water from cultivated land is 3.8 per million.

The examinations of waters made by Mr. Warrington were almost entirely chemical; the only exception was a series of experiments which indicated that a nitrifying micro-organism is contained in deep-well waters, but in very small proportions.—*Sanitary Engineer.*

Cotton Cultivation in Russia.—Minister Lothrop writes to the State Department as follows: "The Imperial Government is making very strenuous and persistent efforts to promote the cultivation of cotton within its own dominions, with the hope to carry the home production to the point of excluding all foreign-grown cotton.

"An article in a late number of the *Journal* of St. Petersburg, compiled from the Moscow *Gazette*, may be found interesting in this connection.

"It has recalled to me a conversation I had this spring with Lieutenant-General Annenkoff, the able and enterprising soldier who has charge of the construction of the Trans-Caspian Railroad. He assured me that he should open the line to Samarcand on November 15 next, and gave me an invitation to attend the formal opening on that day. He said that, within one year, he should be able to deliver Central Asia cotton in Moscow at one-half of the present price of cotton there.

"You will notice that an increase of the duty on cotton is suggested, and as that falls in with the ruling policy, it is very probable that it will be done.

"The *Journal* supposes that in Central Asia, and also in the Trans-Caucasus, the conditions for cotton culture are essentially the same as in the United States. But this is probably not quite accurate.

"As I am informed, in most places irrigation will be necessary. And it will be long before the native cultivators can be inspired with American skill and enterprise. At present, the native cotton is said to be inferior in the strength and length of its fiber. This may be overcome by the introduction of new varieties. The Government has already brought seed and experts in planting from America. It has recently been stated that there was already a considerable cotton plantation near Merv, owned and operated by Americans; but this was afterward denied, and it was added that a concession of land for that purpose had been refused to a company of Americans. I do not know what the fact is."

The article from the *Journal* of St. Petersburg, above referred to, says: "To free our manufacturers from their dependence upon the producers of the other side of the water, and to avoid the obligation of paying dear for a product which could be cultivated in Russia, it is only necessary to encourage its cultivation. That would not, says our cotemporary, be so difficult as one would think, for all the essential conditions for cotton cultivation are united in the south of Russia. The Trans-Caucasian country, as well as our possessions in Central Asia, differ in no way as to climate from the United States.

"The proof of this is that the best kinds of American cotton are cultivated there with success, and considerable progress has already been made, in spite of the little care given by us to cotton. Thus, only six years ago, but 21 poods of American cotton were exported from Taschkend, whereas last year over 25,000 were gathered.

"In the province of Erivan, where a few years since this cultivation was in its infancy, it is now assuming the appearance of a real industry. These examples prove sufficiently that cotton could be cultivated with us on a great scale. Only a little more energy is required and the capital necessary for so vast an enterprise. Without help from the State no result could be reached, because, independently of the necessary works for irrigation of the plantations, the installation of which would be very costly, it is indispensable that a credit should be opened to the planters sufficiently large for their first wants, and notably for the purchase of seed of good quality.

"The objections to this project, which would have for basis the impossibility of weighing down the budget with a new expense, are groundless. Without creating new articles of expenditure, the cotton industry itself might be made to pay for the creation and improvement of this branch of agriculture."

The imports of cotton into Russia over the European frontier in 1886 were 7,247,651 poods, or about 53,100 bales of 500 lbs. each.

Tramways in France.—At the beginning of the present year there were 436¼ miles of tramway or street railroad in operation in France, an increase of 5½ miles over the preceding year. The total amount of capital invested in the various lines is about $27,000,000, or a little over $60,000 a mile. Of this sum, about 45 per cent. was represented by permanent way and 55 per cent. by equipment and working stock. The traffic receipts in 1886 were, in round figures, $7,075,000; the working expenses, $5,820,000, and the net earnings $1,255,000. The net earnings were thus about 4.65 per cent. on capital invested. The returns varied greatly in different cities, however, the lines in Bordeaux having paid 30 per cent.; in Havre 13, and in Lyons 9 per cent., while in several of the smaller cities the working expenses exceeded the traffic receipts. The five companies owning the Paris lines returned net earnings amounting to an average of 3.54 per cent. on capital.